Massive Point-to-Point and On-Demand Air Transportation System Investigation

Phase 3 Self-Assessment Results

March 2005

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and

Nicole Racine

Titan

Outline

- Assessment Questions
- Approach/Metrics/Results
  - ACES Assessments
    - Chicago Regional Benefit-Cost
    - Chicago Regional Sensitivity Analysis
    - NAS-wide Demand Generation
    - NAS-wide Benefits
  - Extended Terminal Simulation
  - Human Factors
- Lessons Learned
- Issues/Challenges

Self Assessment Questions To Be Addressed

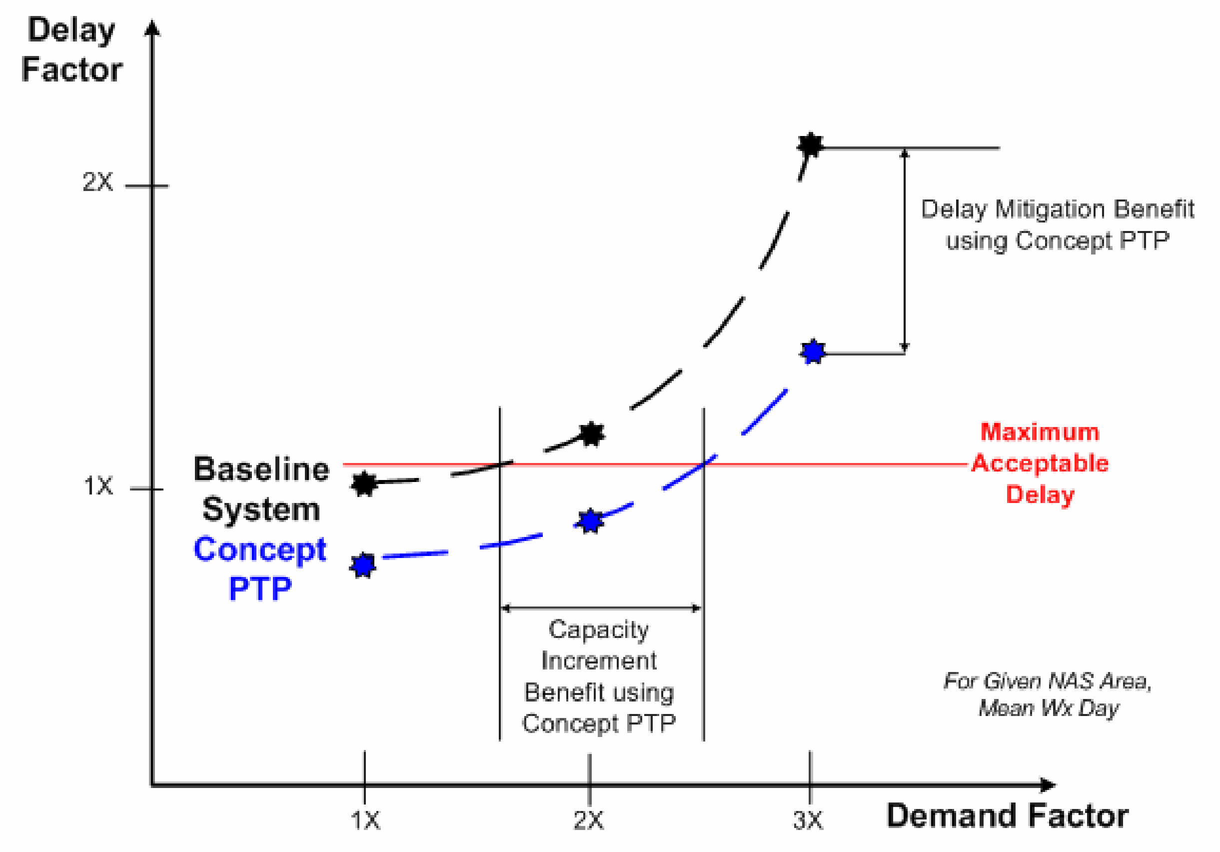
- Is Concept PTP Economically Beneficial?
  – If so, what does the Cost-Benefit Analysis show in terms of benefits and benefit-cost ratio?
  – *Approach:* ACES

- Is Concept PTP Technically Feasible?
  – If so, what are the Technology Requirements?
  – *Approach:* Extended Terminal Simulation

- Is Concept PTP Operationally Viable?
  – If so, what are the Human Performance Requirements?
  – *Approach:* Questionnaire, Requirements Analysis, SME Interviews

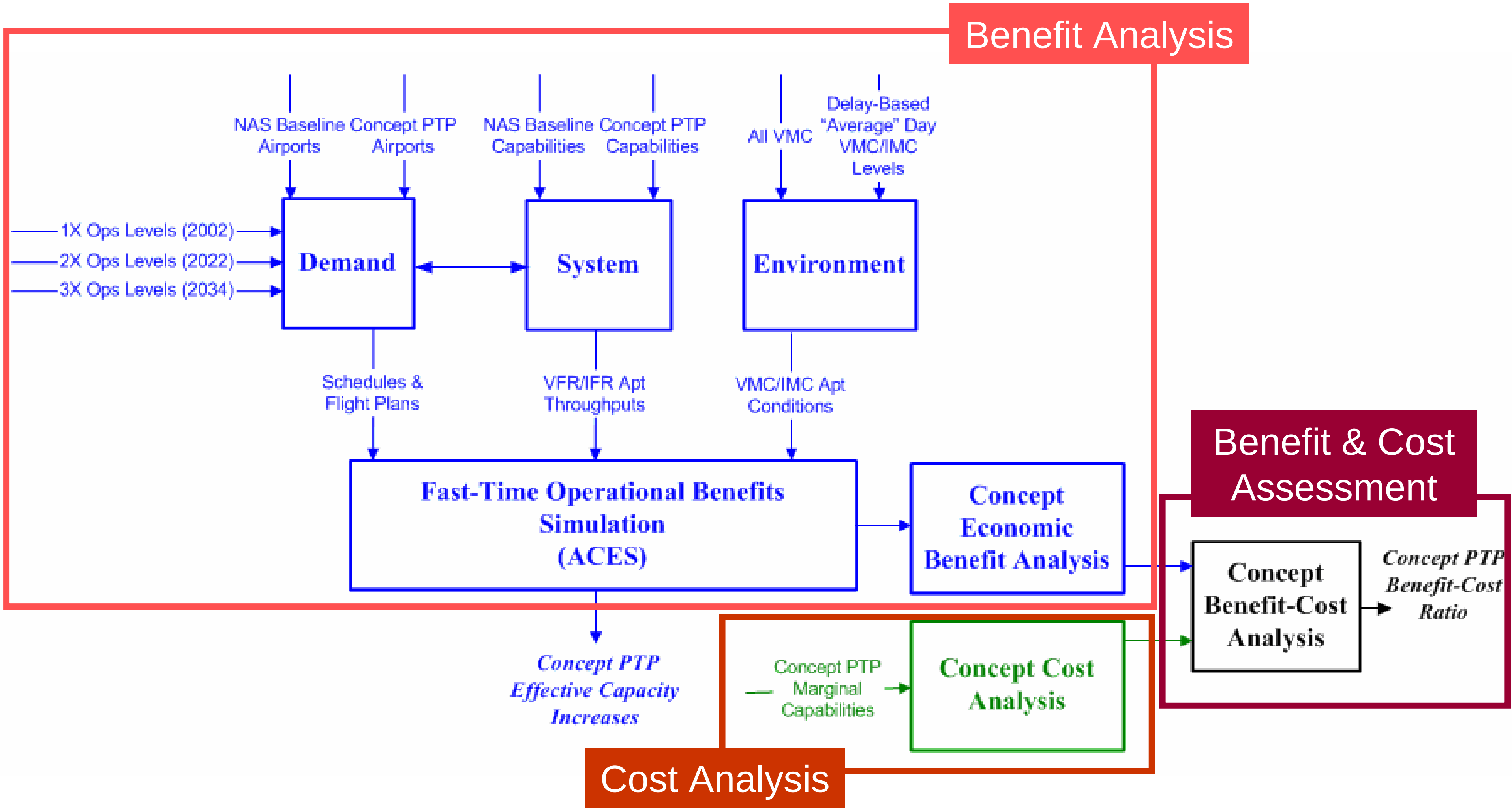
Issue of Economic Impact

- **Question: If the PTP system works as hoped, is there a feasible PTP business case proposition to be made to the aviation stakeholders?**
- **Hypothesis: We think so, due to the significant benefits provided by Concept PTP relative to a 2020-timeframe NAS problem.**



- **We need to quantify the operational PTP costs and benefits to validate this hypothesis**

Approach:
ACES Assessment Overview



ACES Assessment Metrics

- Average aircraft delay in terms of:
  - Actual gate arrival time – Unobstructed gate arrival time
- Effective capacity: throughput for a given maximum acceptable average delay value
- Annualized system life cycle costs; and
- Concept PTP auxiliary airport system benefit-to-cost ratio

Outline

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  - ACES Assessments
    - Chicago Regional Benefit-Cost
    - Chicago Regional Sensitivity Analysis
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    - NAS-wide Benefits
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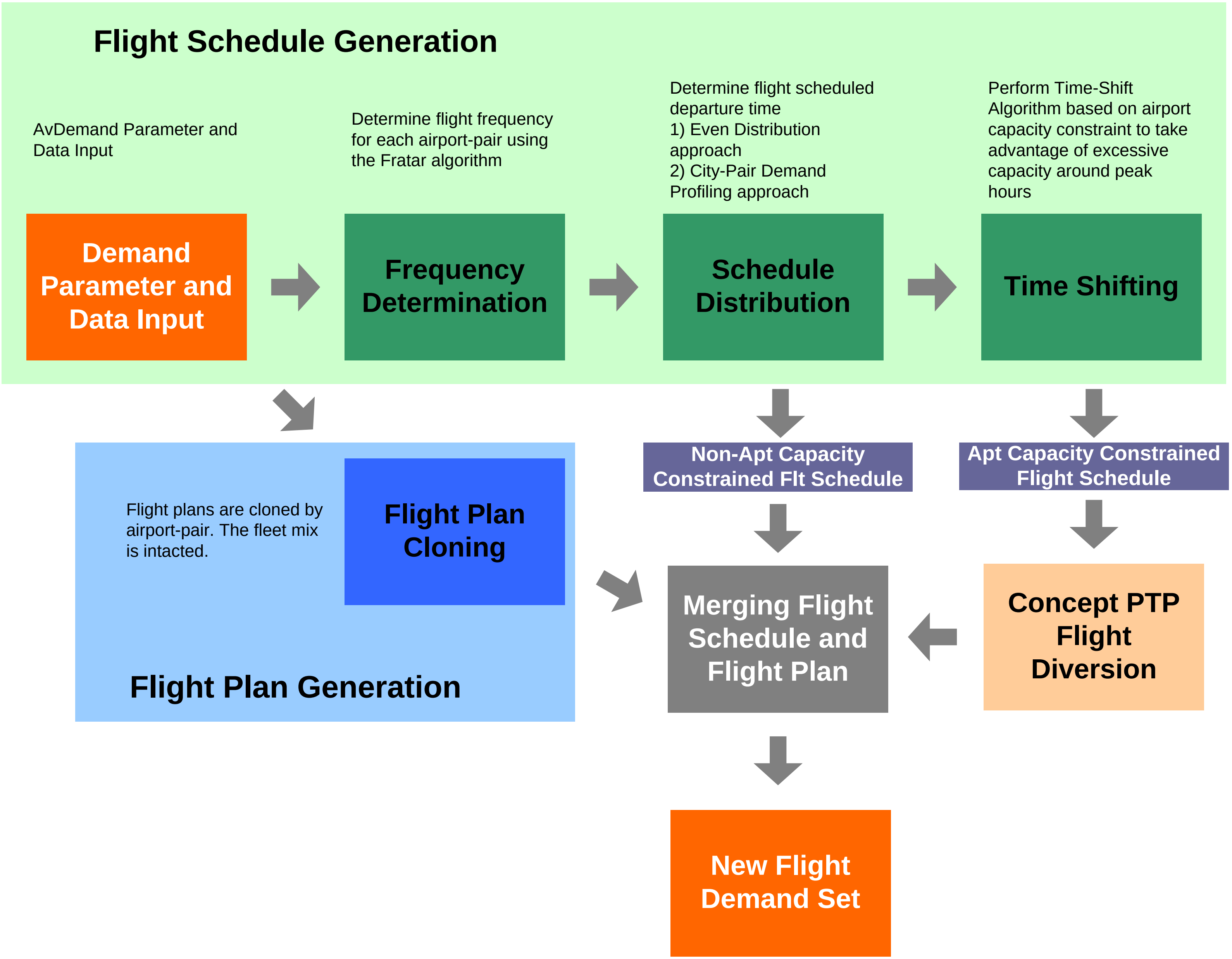
NAS-Wide Demand Set Generation



Baseline NAS-Wide Demand Sets Generated

Demand Scenario	Airport Growth and Demand Scope	FltGen Processed
1X Baseline+TimeShift	May 17, 2002 ETMS Demand International	NO
1X Baseline+TimeShift	May 17, 2002 ETMS Demand CONUS	NO
1X Baseline+TimeShift	May 17, 2002 ETMS Demand 250 Airports	NO
1X Baseline+TimeShift	May 17, 2002 ETMS Demand 250 Airports	YES
2015 Baseline+TimeShift	TAF 2015 250 Airports	YES
2020 Baseline+TimeShift	TAF 2020 250 Airports	YES
2X Baseline+TimeShift	TAF 2020 with 2X Target Growth 250 Airports	YES

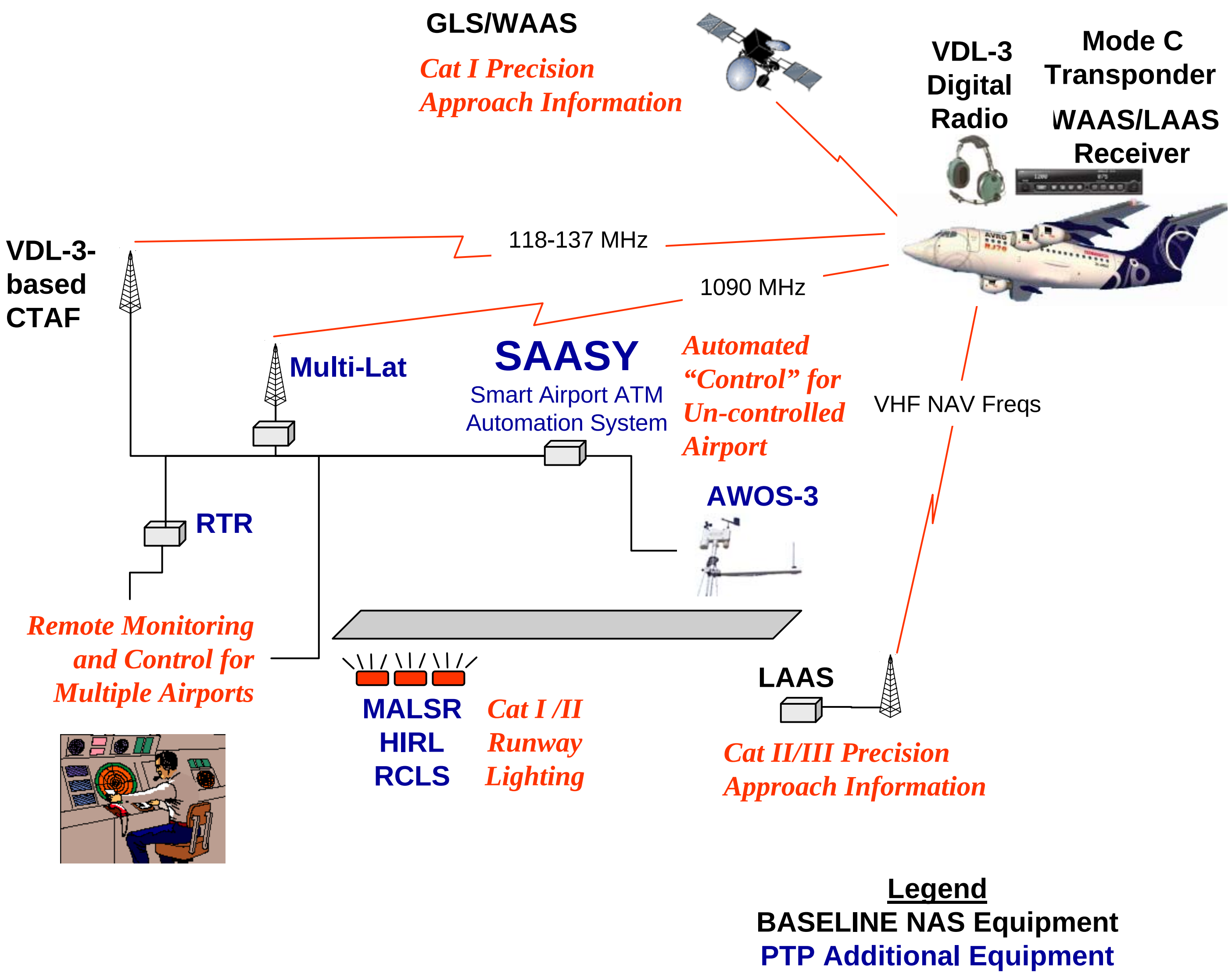
PTP NAS-Wide Demand Sets Generated

Demand Scenario	Airport Growth/Distribution Factor and Demand Scope	FltGen Processed
2015 PTP	TAF 2015, D/C=1, AvroRJ85 PTP Aircraft, 297 Airports, 47 of these airports are additional PTP airports	YES
2020 PTP	TAF 2020, D/C=1, AvroRJ85 PTP Aircraft, 325 Airports, 75 of these airports are additional PTP airports	YES
2X PTP	TAF 2020 with 2X Target Growth, D/C=1, AvroRJ85 PTP Aircraft, 428 Airports, 178 of these airports are additional PTP airports	YES

Outline

- Assessment Questions
- Approach/Metrics/Interim Results
  - ACES Assessments
    - Chicago Regional Benefit-Cost
    - Chicago Regional Sensitivity Analysis
    - NAS-wide Demand Generation
    - NAS-wide Benefits
      - **VMC: PTP Airports**
      - **Bad Weather Day: PTP Airports**
      - **VMC: PTP Airports + PTP Airspace**
  - Extended Terminal Simulation
  - Human Factors
- Lessons Learned
- Issues/Challenges

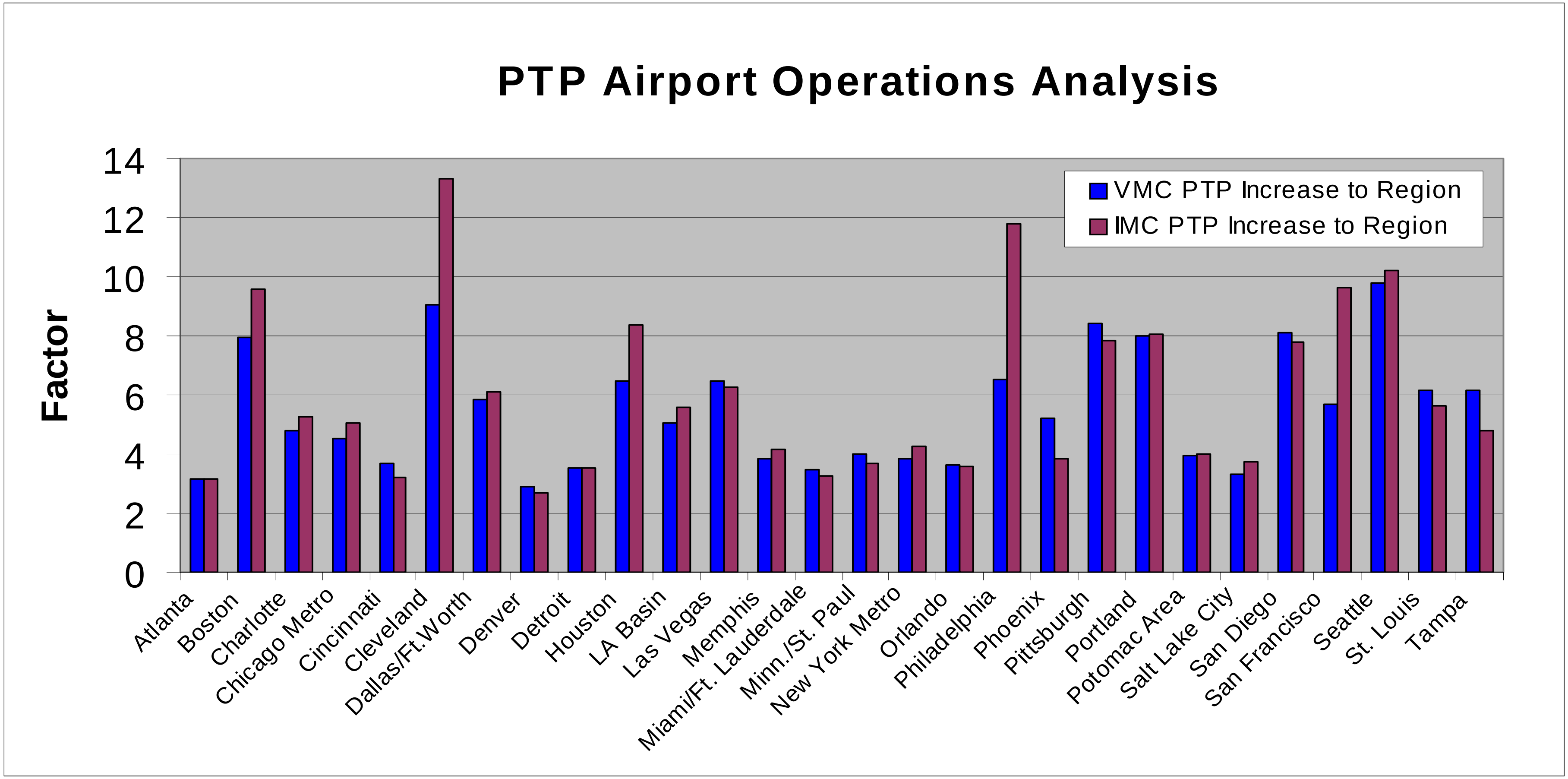
PTP Core Idea 1: Nontowered and Towered Airport Automation



NAS-wide Benefit Results

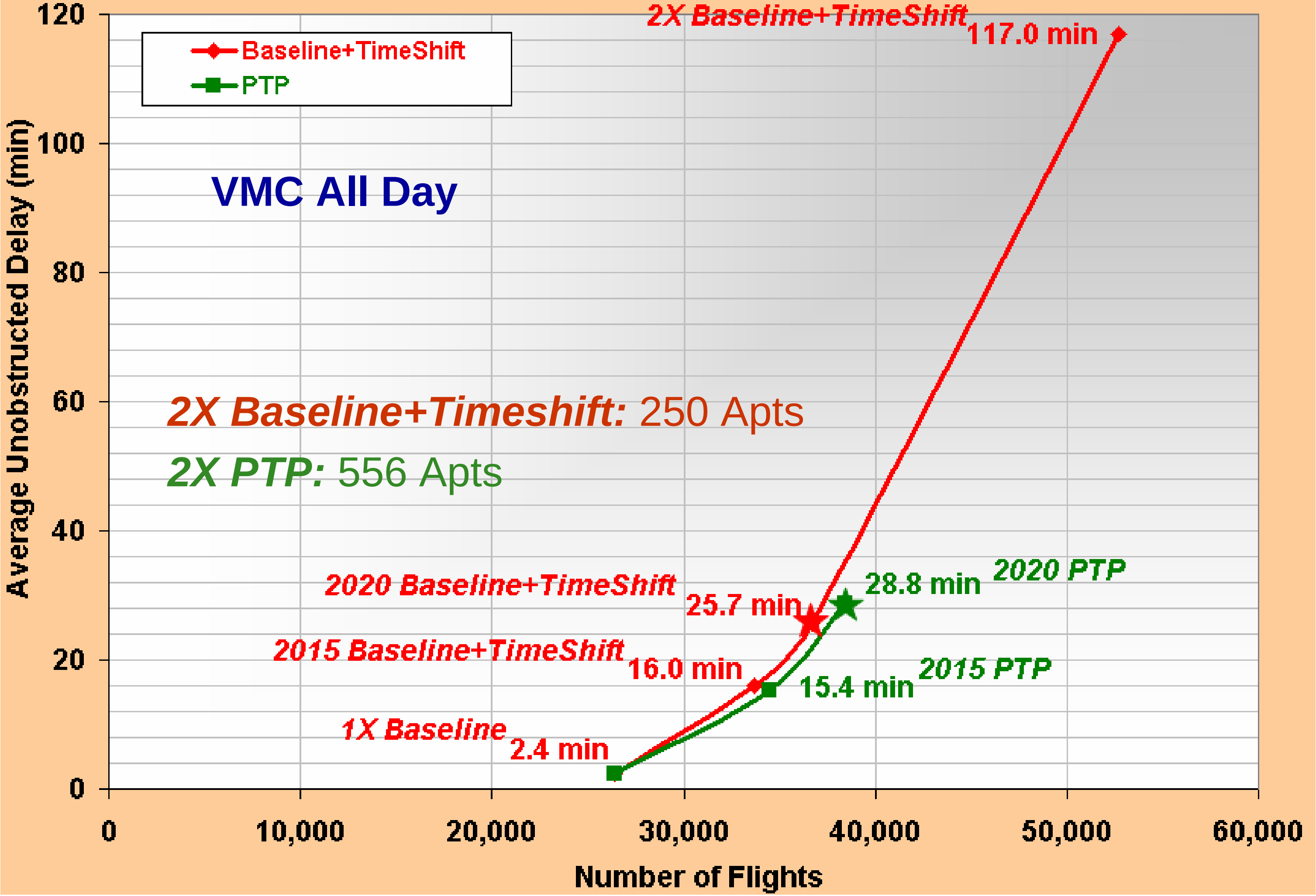
- **Using Diversion of 34 CONUS OEP Apt Demand to PTP Auxiliary Apts**

$$PTP\ Increase_{\mathrm{Region}} = \frac{\sum All\ Airport\ Capacity_{\mathrm{Region}}}{\sum OEP\ Airport\ Capacity_{\mathrm{Region}}}$$

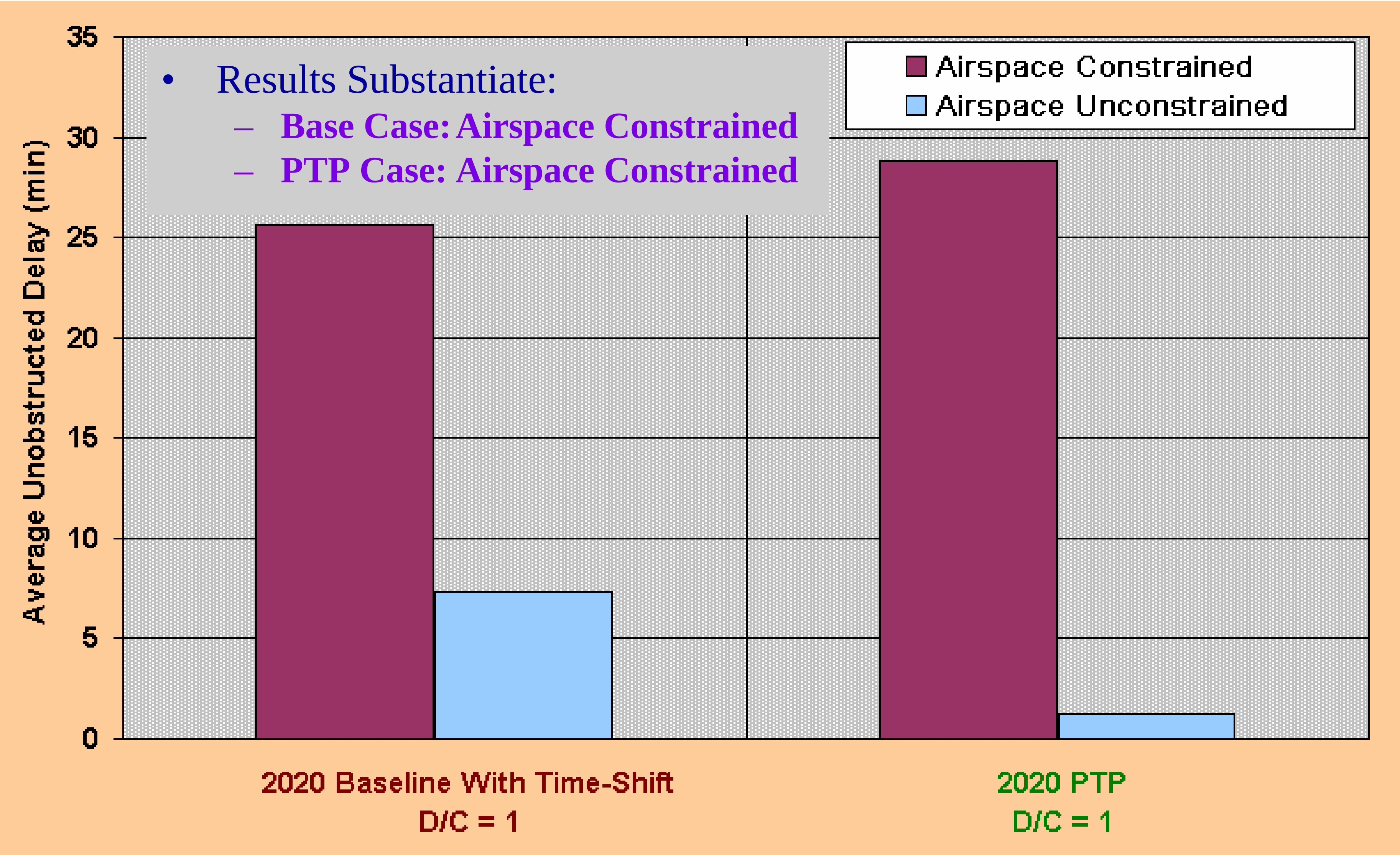


NAS-wide Benefit Results

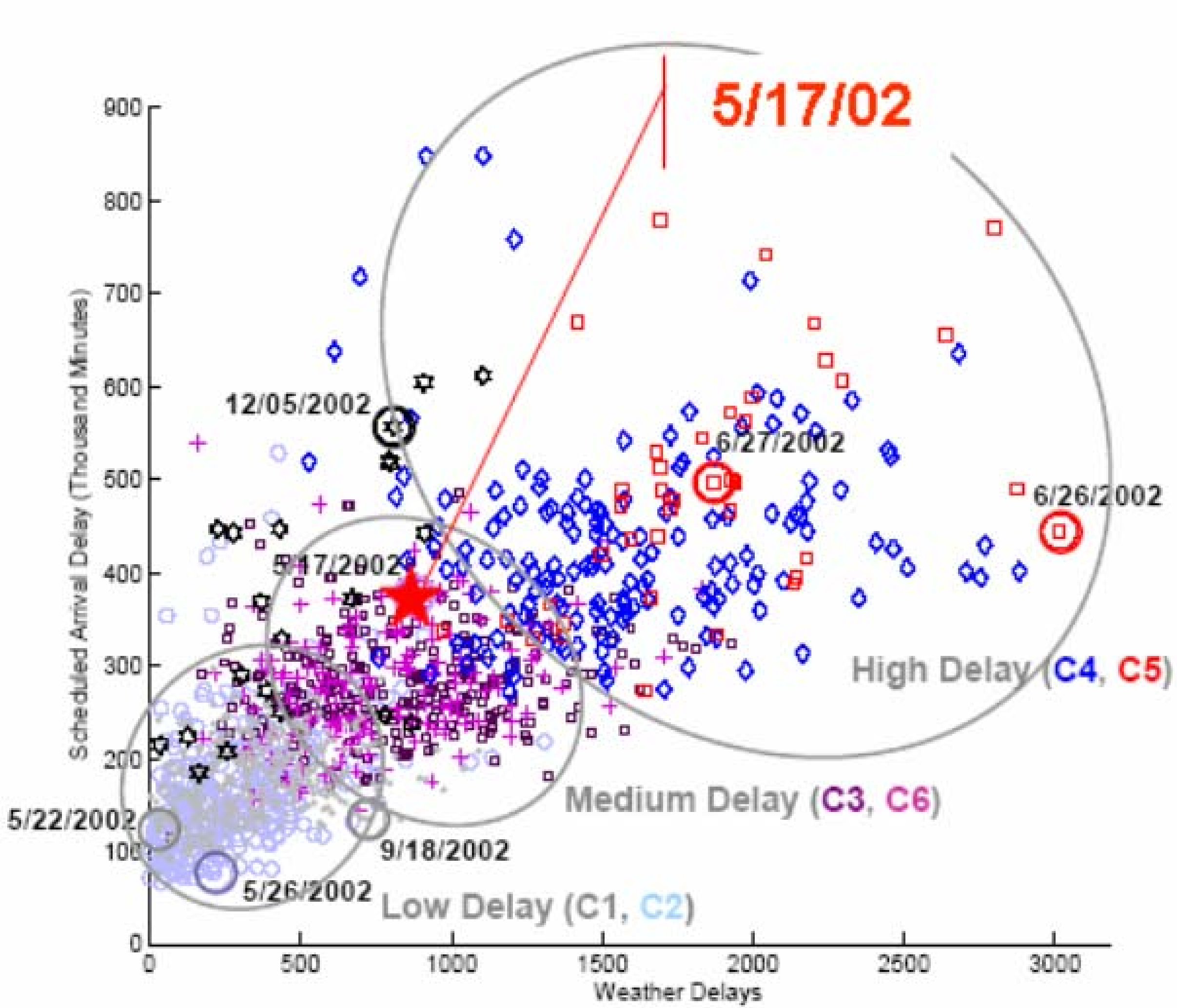
- **NAS-Wide CONUS Demand and Capacity Levels**
- **ACES Build 2.0.3 (incl. en route queuing, CD&R, no AOC cancellations)**



NAS-Wide Baseline vs. PTP Delay Causes

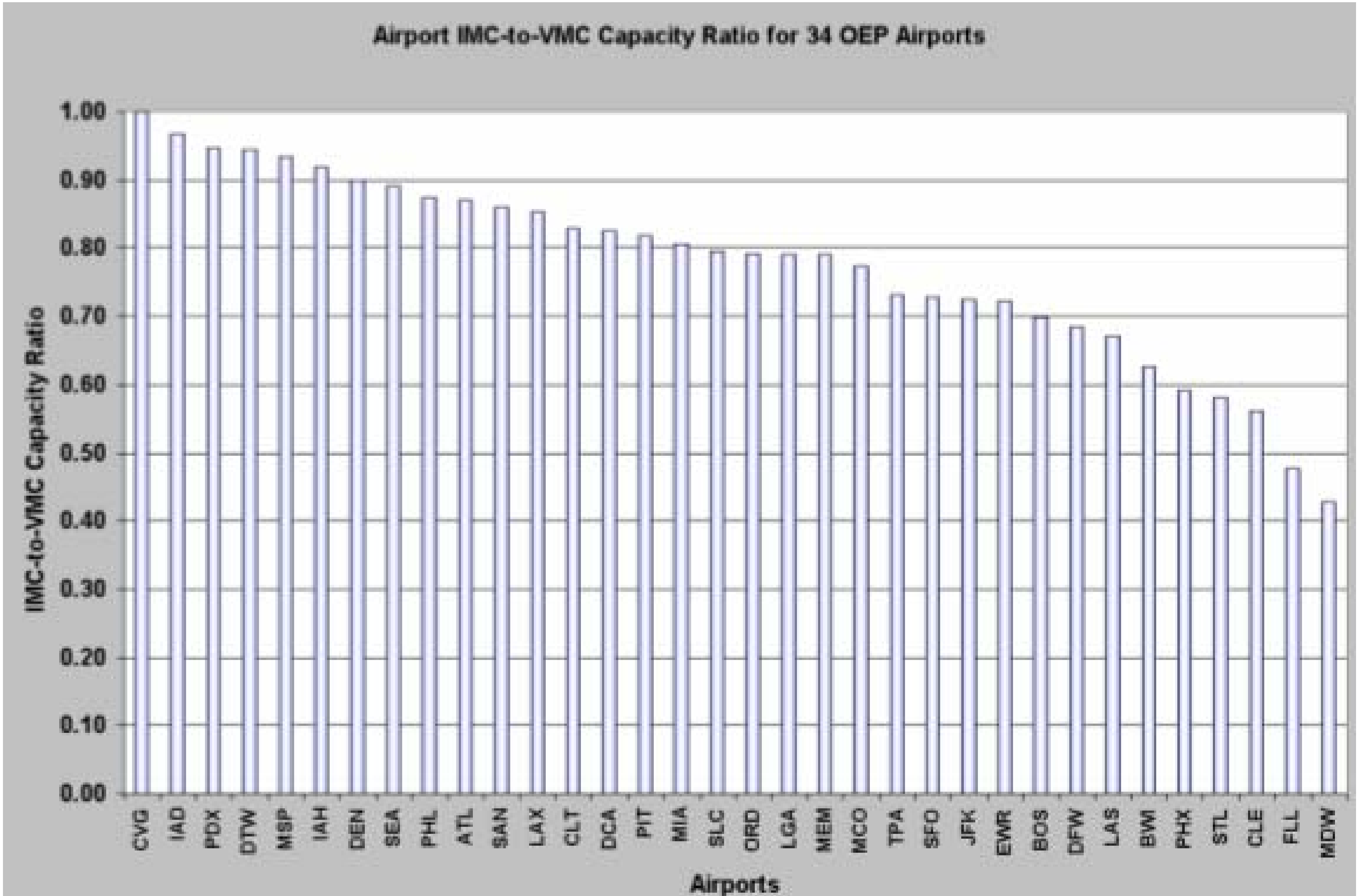


Choice of "Bad Weather" Day

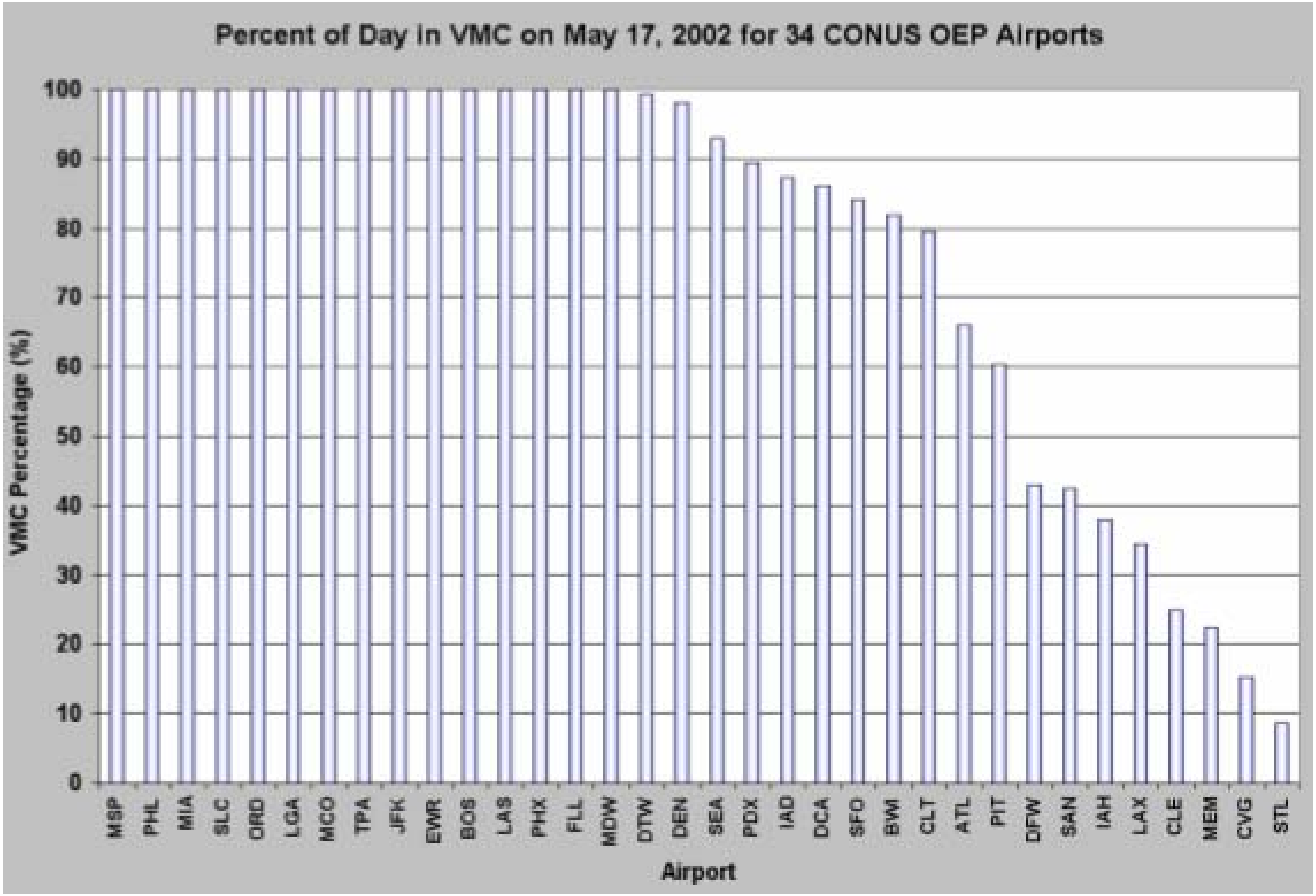


Source: Krozel, J., and Penny, S., "Types of Days For Selected ACES Simulation Scenarios," June 2004

“Bad Weather” Day OEP Airport Performance



5/17/02 “Bad Weather” Day Statistics



5/17/02 "Bad Weather" Day Metrics

$$Cap_{adj} = Cap_{VMC}(1 - K) + Cap_{IMC}K$$

where:

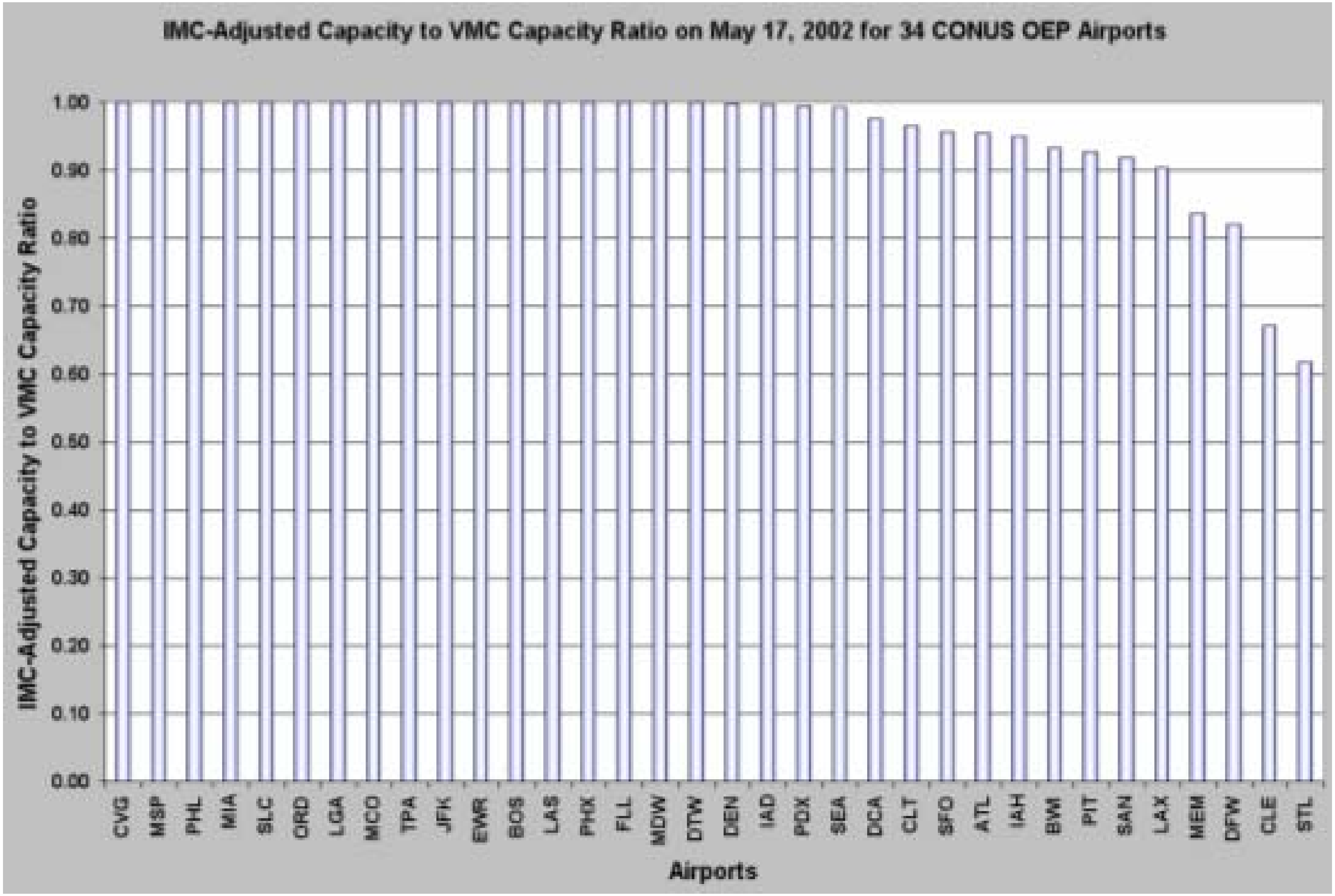
- Cap_{adj} is the IMC-adjusted hourly capacity,
- Cap_{VMC} is the "optimum rate" hourly capacity [ACB01],
- Cap_{IMC} is the "reduced rate" hourly capacity [ACB01], and
- K is the fraction of all of a given day's quarter-hours that are defined as IMC for a given airport

Thus,

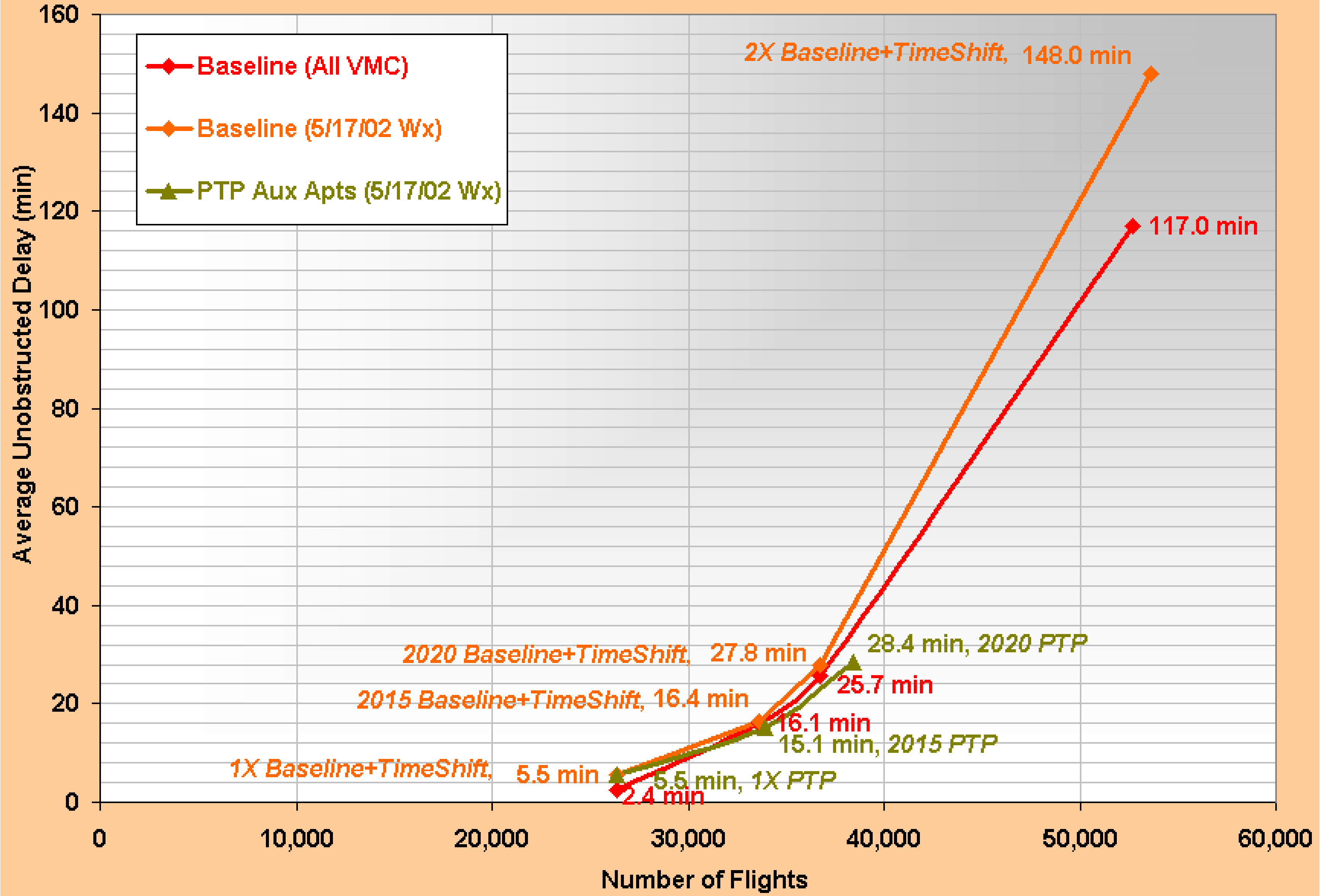
"IMC Weather Index" = Cap_{adj} / Cap_{VMC}

and, therefore, is equal to 1.0 when an airport achieves its VMC capacity value over the entire day and < 1.0 when both the airport IMC capacity is less than VMC capacity and some fraction of the day's time was at IMC

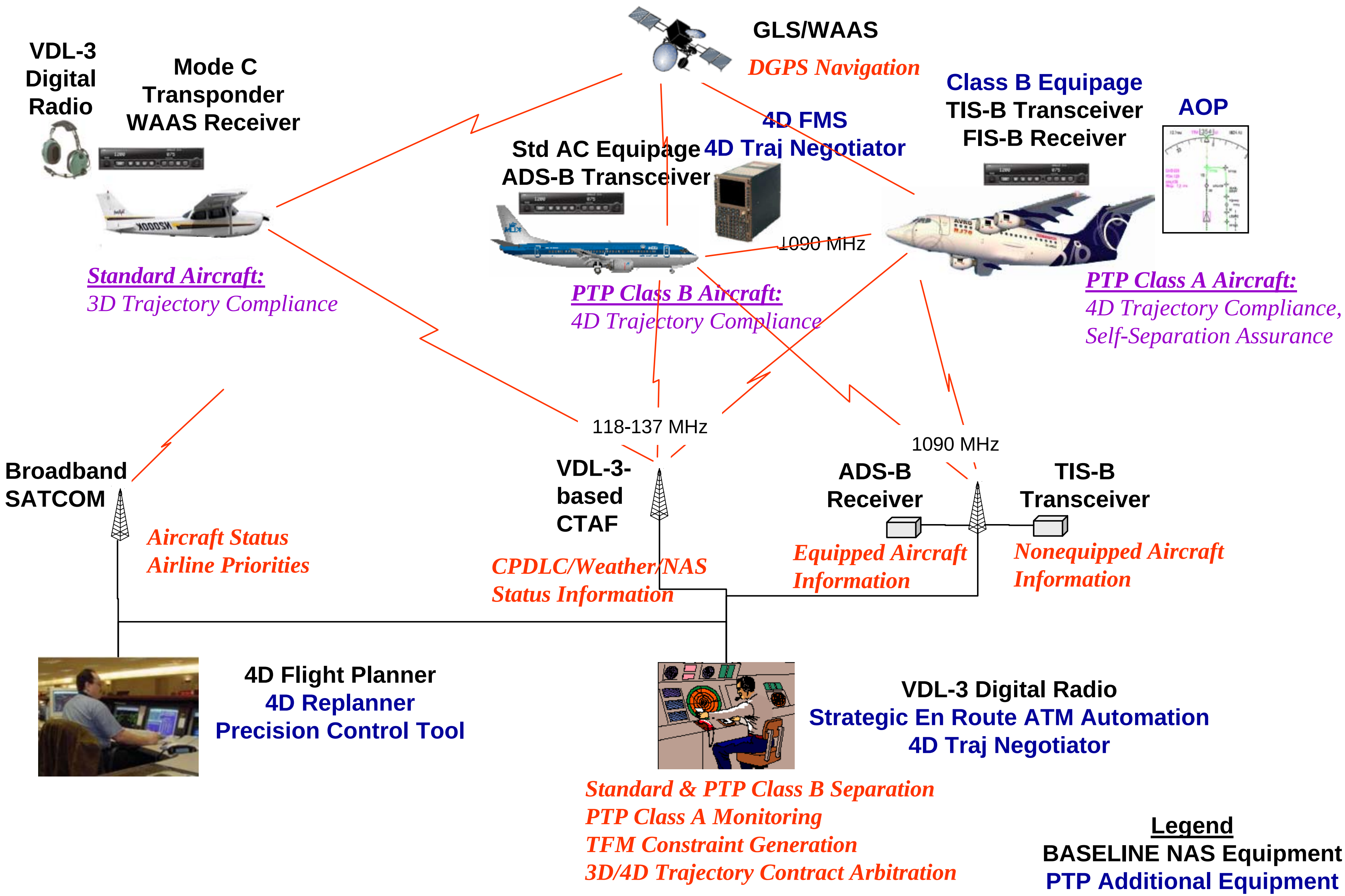
5/17/02 “Bad Weather” Day Statistics



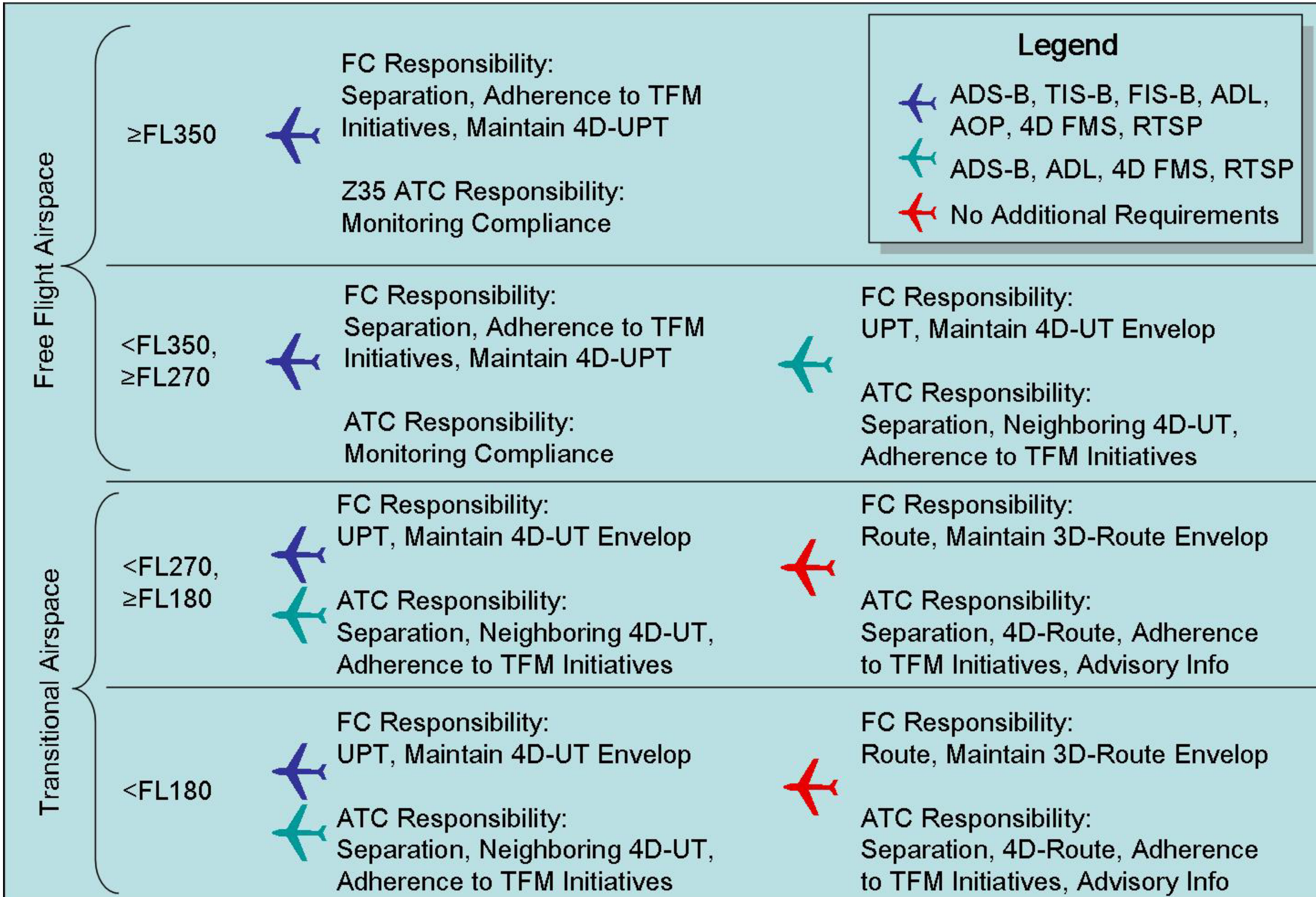
5/17/02 "Bad Weather" Day PTP Results



PTP Core Idea 3:
4D En Route Self-Separation and Trajectory Negotiation



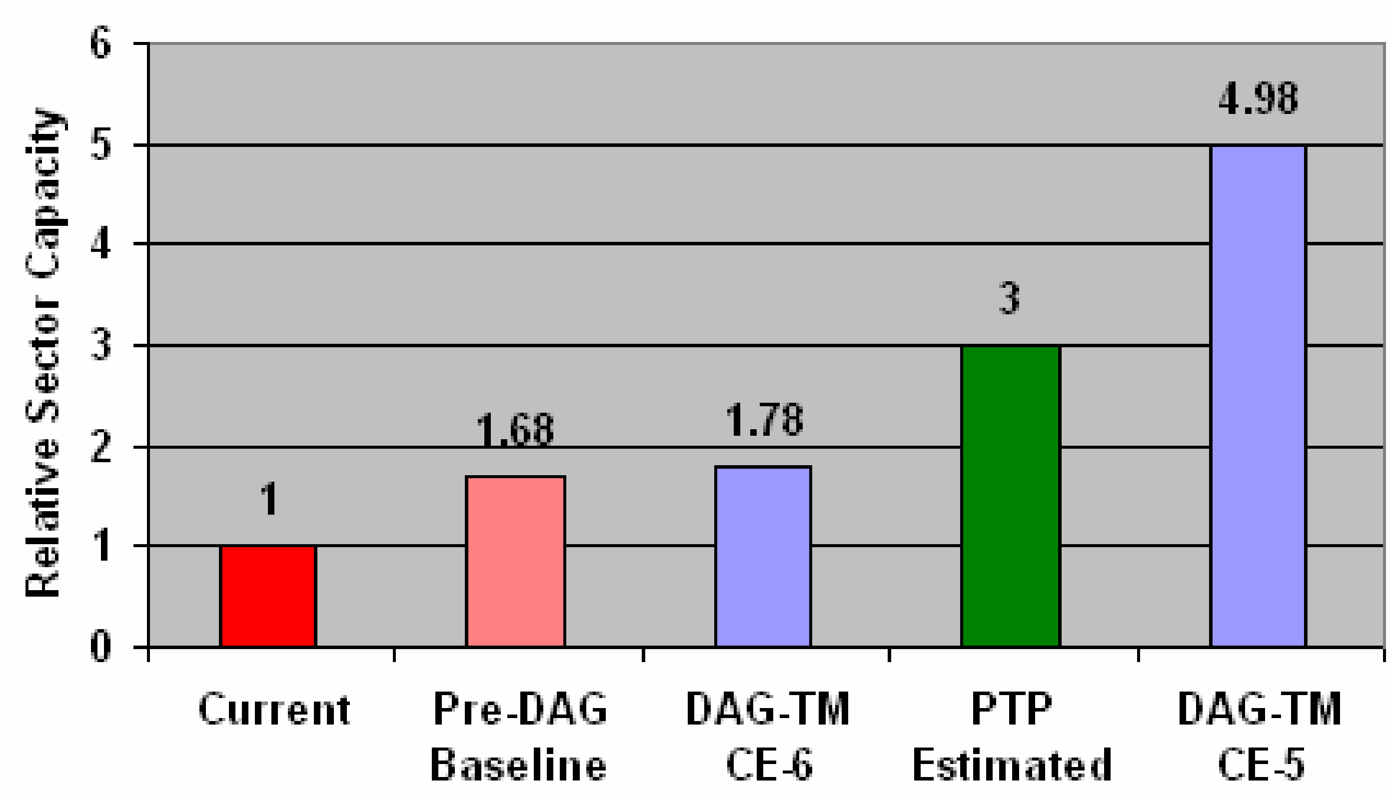
PTP Core Idea 3 Roles and Responsibilities and Aircraft Equipage Types



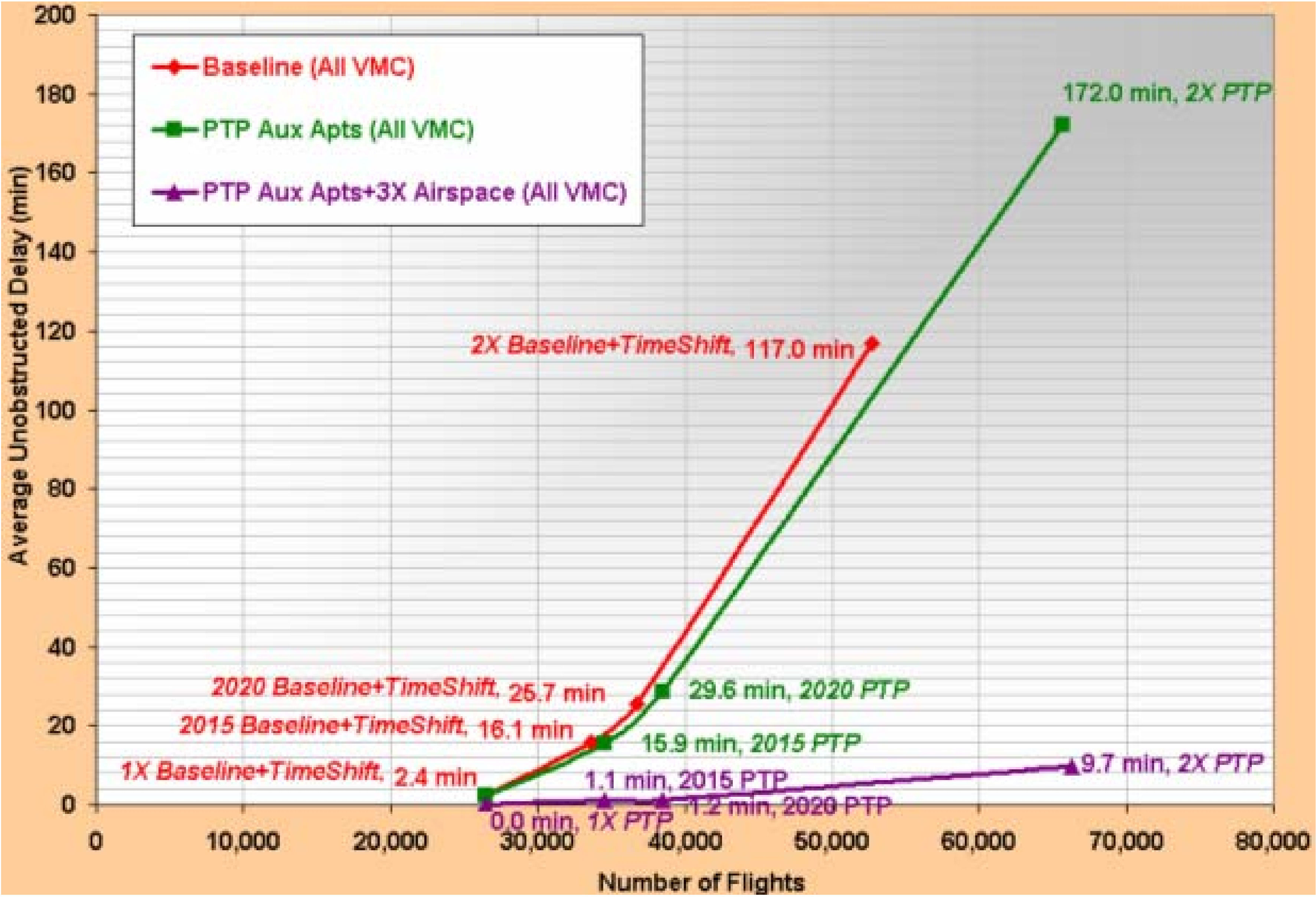
PTP Airspace Capacity Estimation

	Aircraft Equipage Level			
	15%	50%	85%	100%
CE-5 Sector Capacity Increase from Pre-DAG Baseline	17%	73%	330%	(no workload-based sector capacity limit)
CE-6 Sector Capacity Increase from Pre-DAG Baseline	7%	8%	10%	11%

Source: Computer Sciences Corporation, "Single-Year, NAS-Wide Benefits Assessment of DAG-TM CEs 5, 6, and 11," Version 3.1, Contract NAS2-0014, Sunnyvale, CA, June 2003



VMC PTP Auxiliary Airports + 3X Airspace Capacity Results



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  - *Approach:* Questionnaire, Requirements Analysis, SME Interviews

Issue of Technical Feasibility

- Question: If we provide more potential capacity by increasing the number of airports used, is it possible to safely pack 2X more passengers into 3X more aircraft into the airspace leading to and from those runways?
- Hypothesis: We think so, by harnessing the capabilities of 4D FMS, ADS-B, RNP, ATM automation, and FMS-ATM integration via data link.

MSP Airspace w & w/o FMS

Figure 2.2 Northwest Airlines A320 Arrivals to Runway 29L, 10–30 May, 1992

Lateral Distribution for FMS a/c at MSP

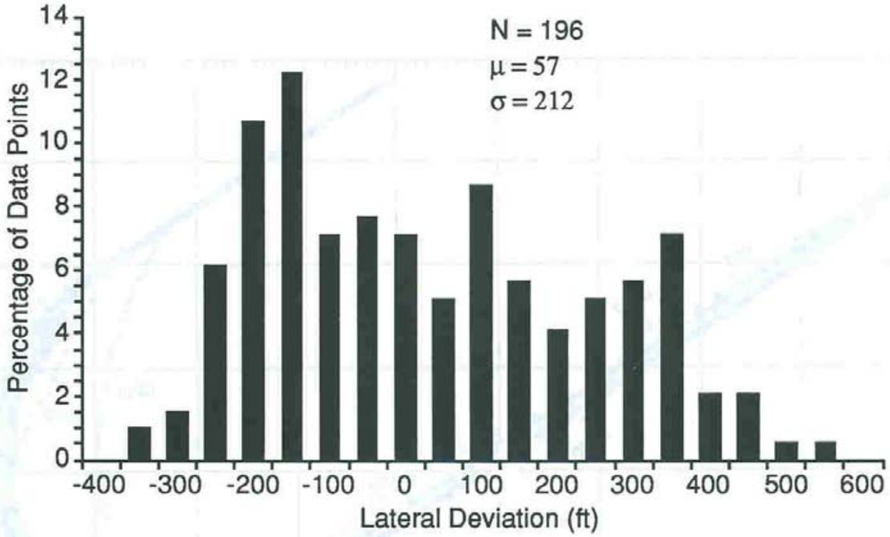


Figure 3.5 Distribution in A320 lateral deviations, downwind segment

- We need to develop and test the technology to validate this hypothesis

Issue of Technical Feasibility

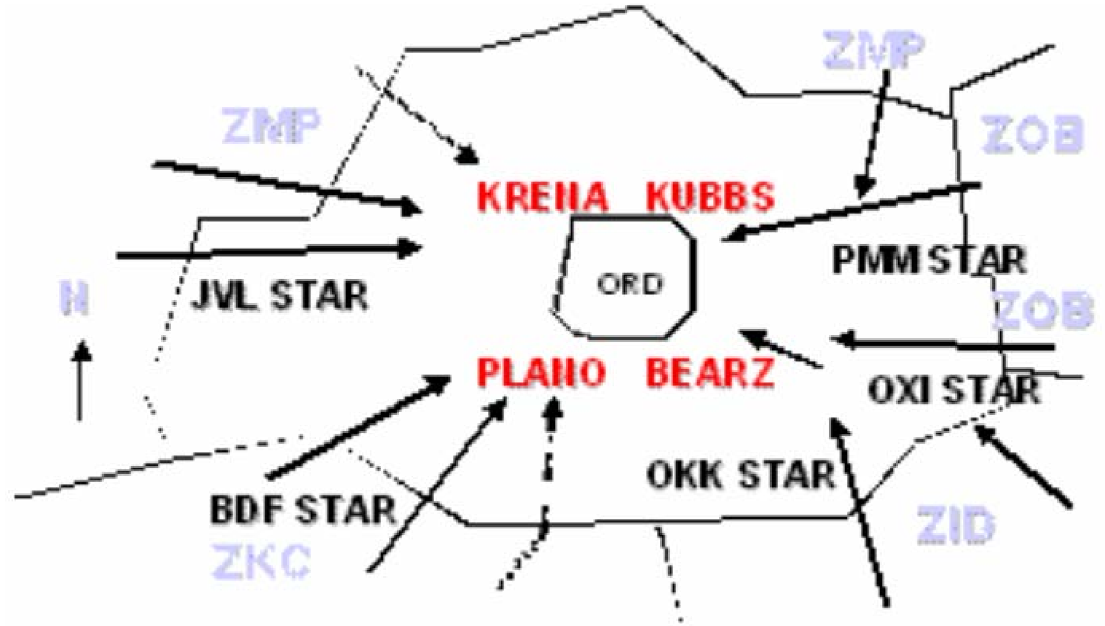
- Graphical representation of New York TRACON arrival traffic total system track errors as a function of technology reveal significant potential decreases in airspace usage

(a) with ATC vectors: ± 1.00nm (b) with GPS-enhanced RNP/RNAV: ± 0.15nm

Source: Dunlay, W.J., "Improved Navigation Technology," UC Berkeley, July 20, 2004

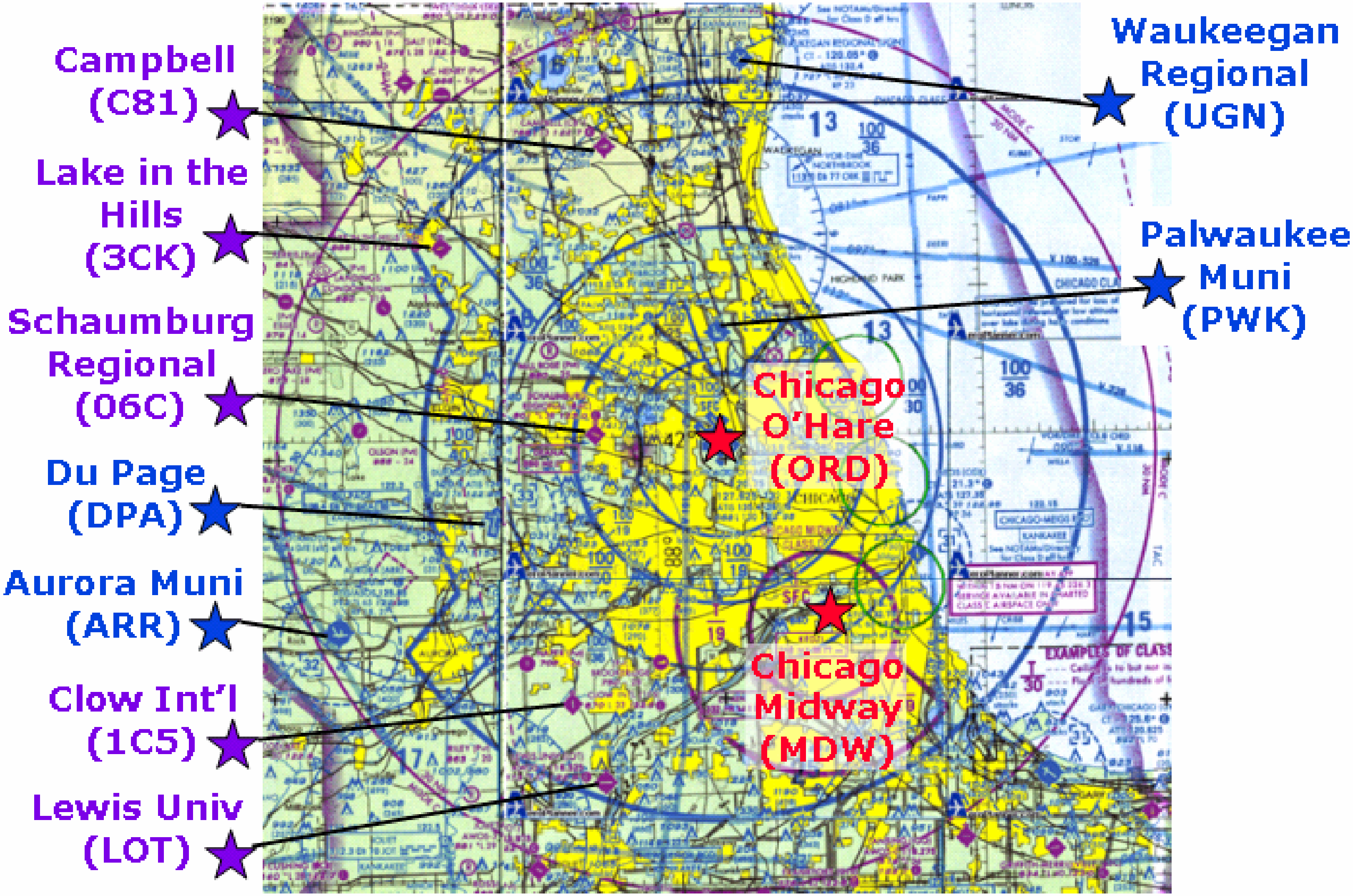
PTP Phase III Extended Terminal Area Simulation: *Main Objectives*

- **Demonstrate the degree of feasibility of conflict-free PTP IFR trajectories into/out of the Chicago metro area using a peak hour of 2X passenger traffic**
  - **Compare PTP vs. Baseline Cases**

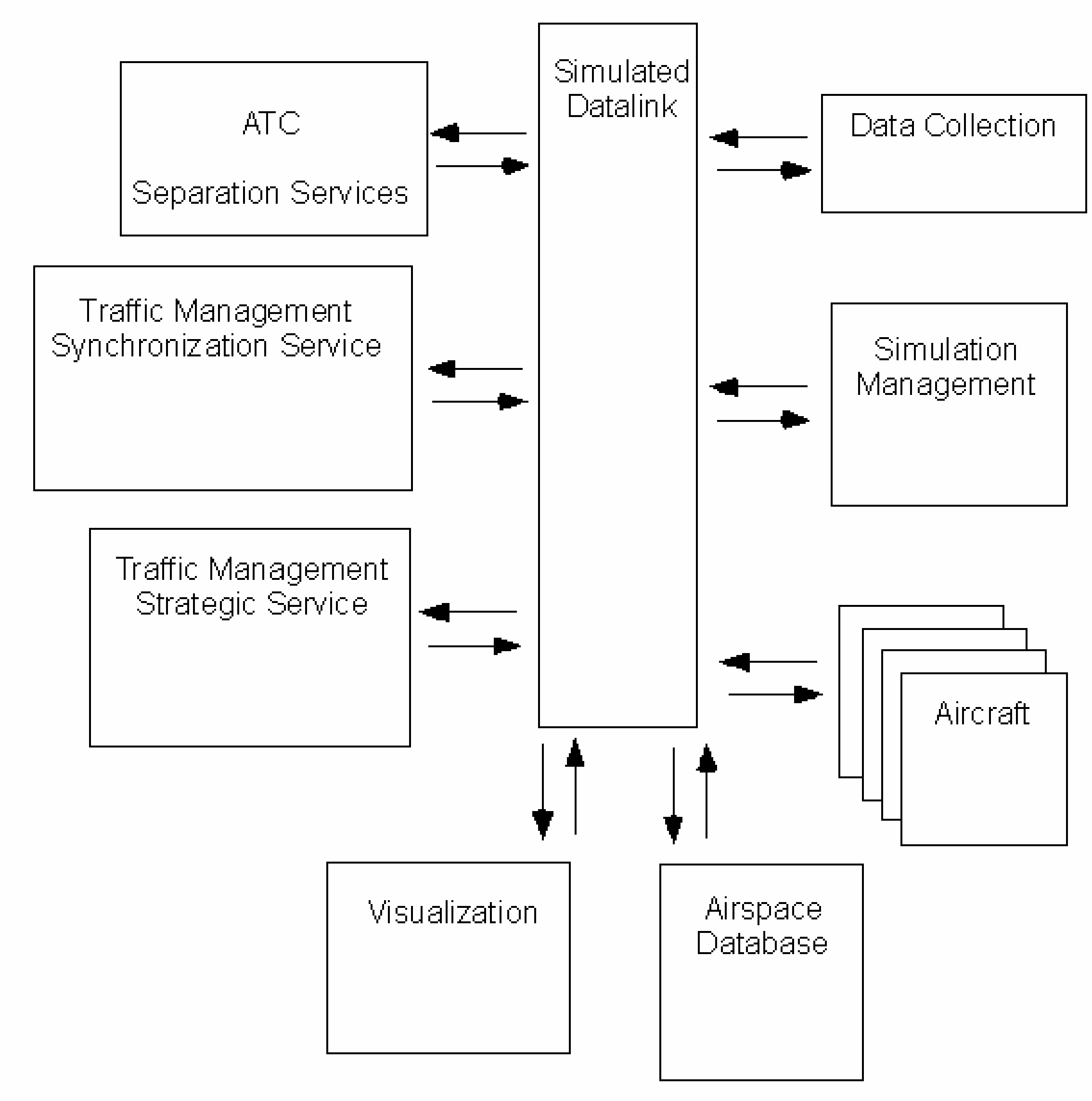


Phase III PTP Technical Feasibility Analysis: *Scope*

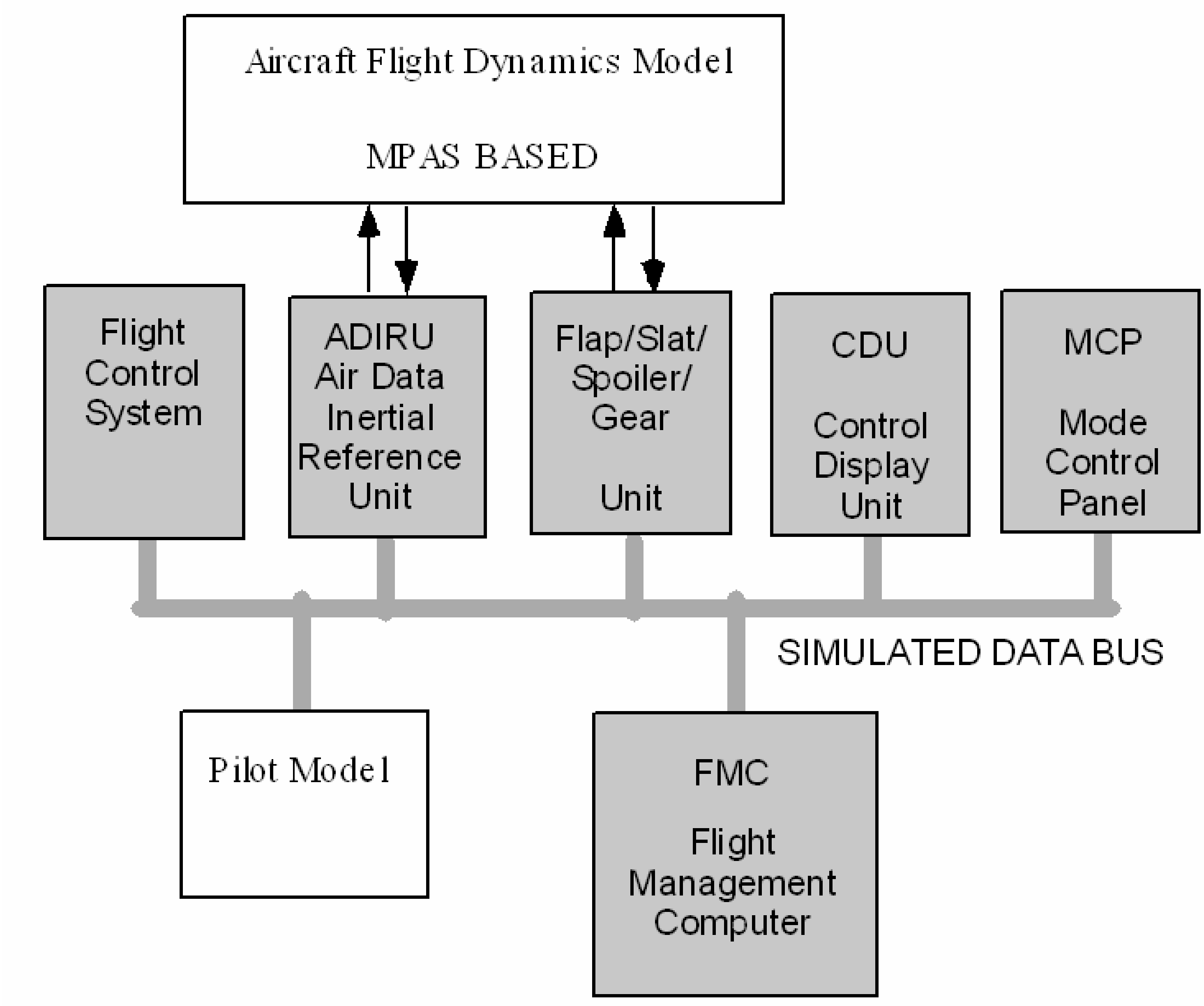
- **Arrivals to Chicago Metro Area Airports**



Terminal Area Simulation Architecture



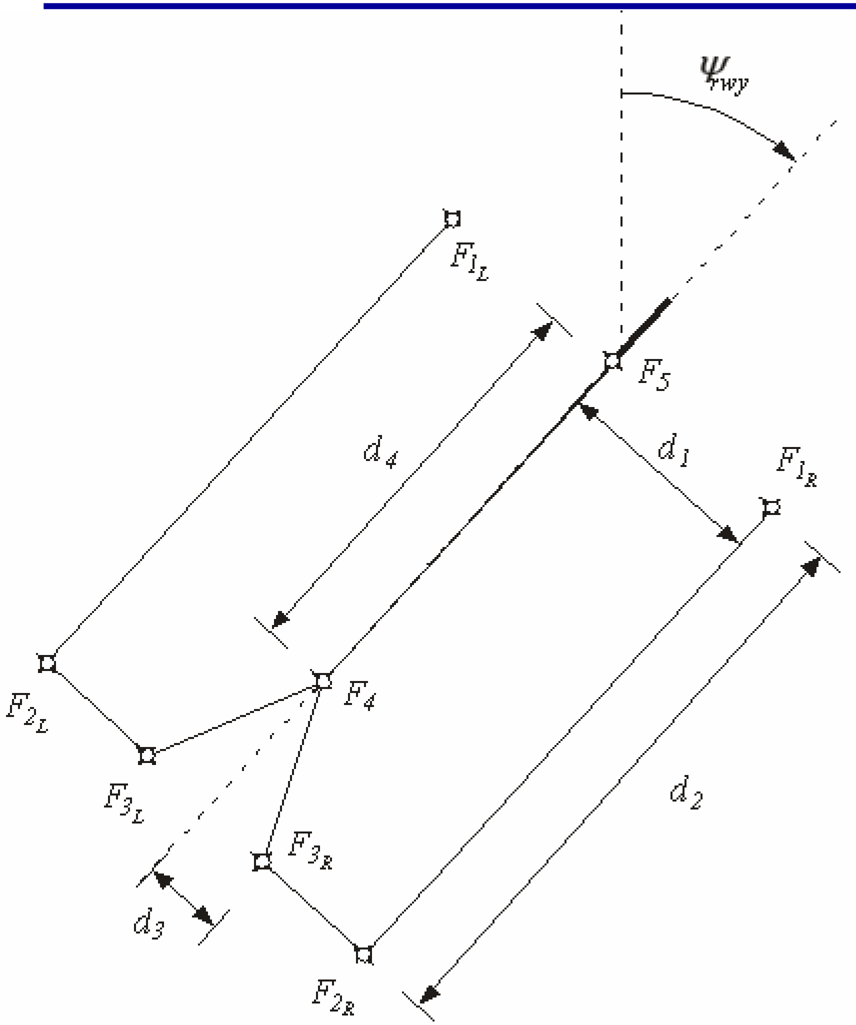
Aircraft Simulation Architecture

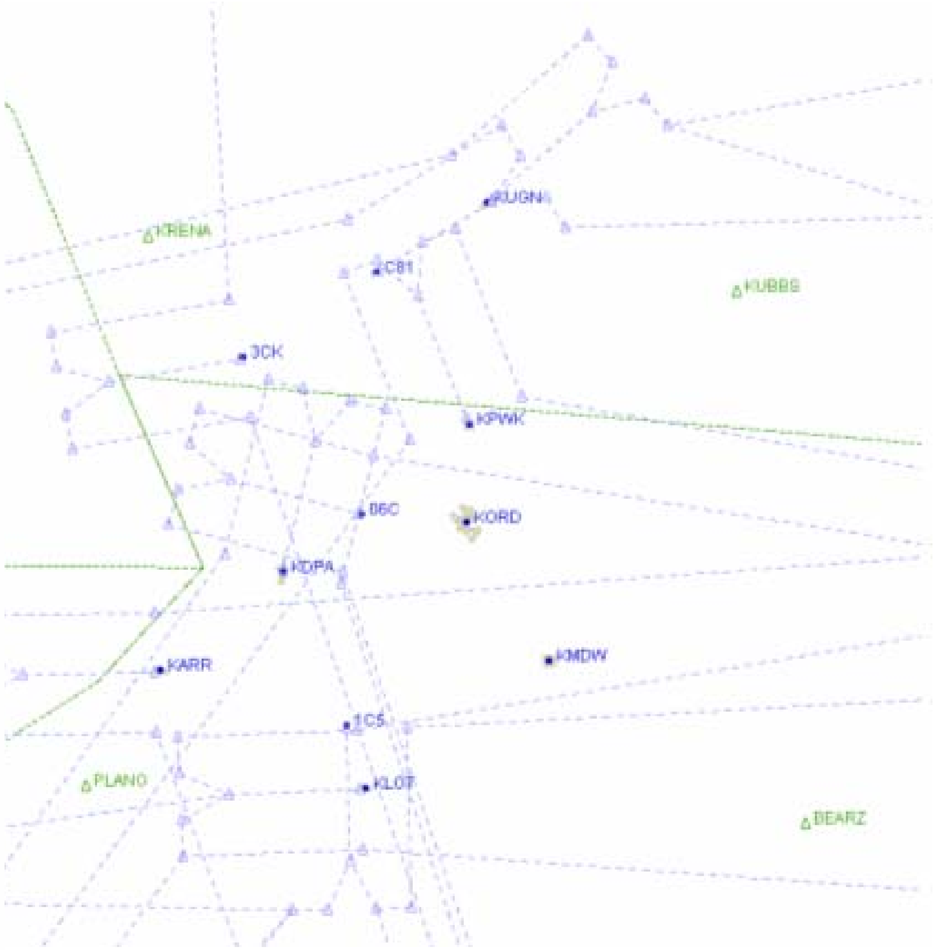


Terminal Area Simulation Aircraft

- 4 DOF aircraft dynamics model based on previous FAA Technical Center model (MPAS)
  - 2 sec time step
- New Flight Control System
  - Modeled on Boeing separate autopilot/autothrottle layout
- New FMS with new vertical guidance
  - Temporary model until ‘real’ FMS is developed
  - Uses original MPAS lateral guidance
- Contains flap and gear schedules
  - Aircraft fly into the terminal area
  - Slow down and extend gear at appropriate times
- ILS-like approach to the runway
  - Includes terminal area autovectoring to instrument approach
- NAS-wide, Elliptical Earth trajectory propagation
- Jet aircraft only – for now
  - Only DC-9/MD-80 implemented

Arrival Autovectoring Structure



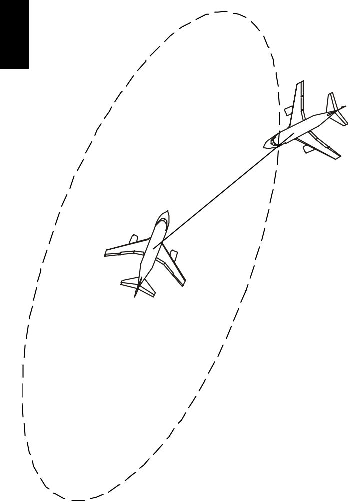


- Generic Structure
- Chicago PTP Airport Structure

Other Terminal Area Simulation Features

- **Reuse of AvDemand (FDS) NAS-wide demand sets**

- **Conflict Detection**
  - **Elliptical Protected Airspace Zones**
  - **Flexible PAZ size definition**

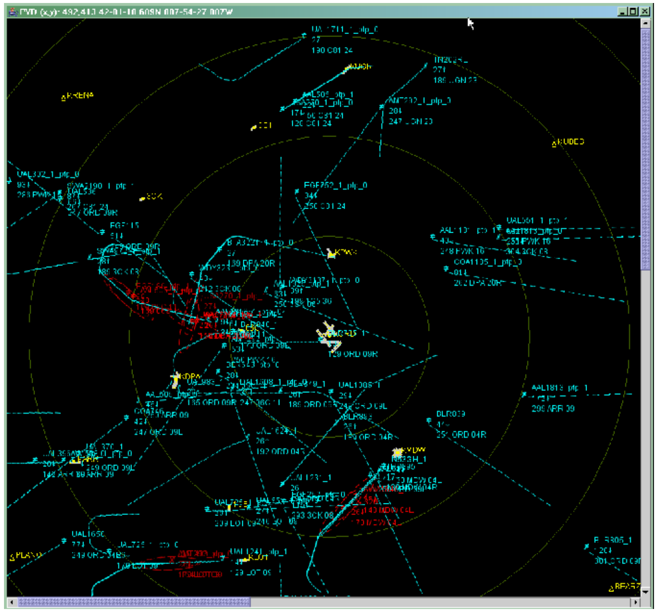


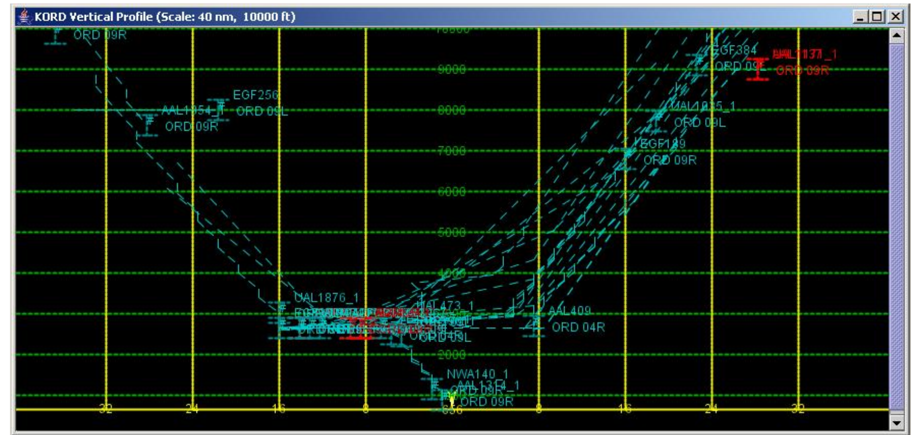
- **Simulation Data Collection**
  - **Actual Aircraft trajectories**
  - **Conflict Data**

- **Post-processed Arrival Runway Delays**

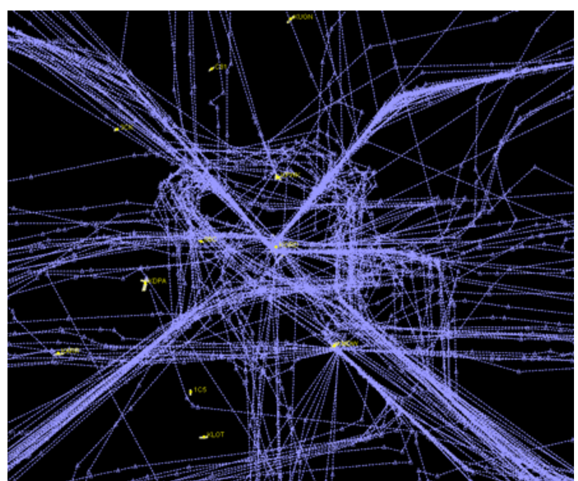
Other Terminal Area Simulation Features

- **Horizontal and Vertical Simulation Displays**





- **Ability to display historical track data**

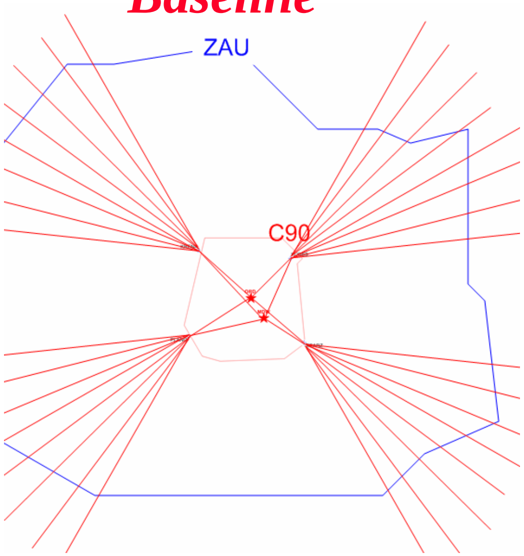


PTP Phase III Extended Terminal Area Simulation: *Analysis and Metrics*

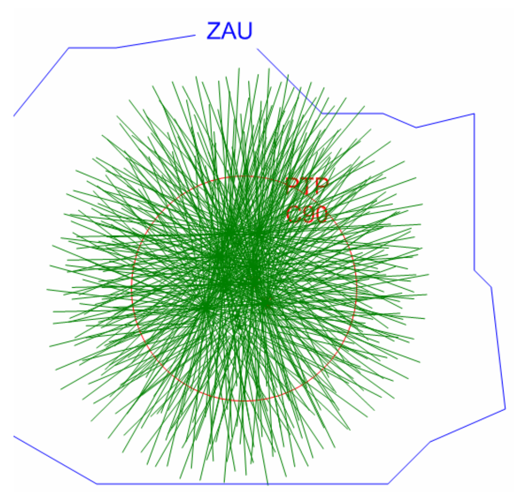
- **Key Analysis:**
  - **2X Baseline peak hour run of four cornerpost ORD/MDW arrivals**

    Vs
  - **2X PTP peak hour run of anchor point-based ORD/MDW + 9 PTP auxiliary airport arrivals using reduced lateral separation criteria**

Baseline



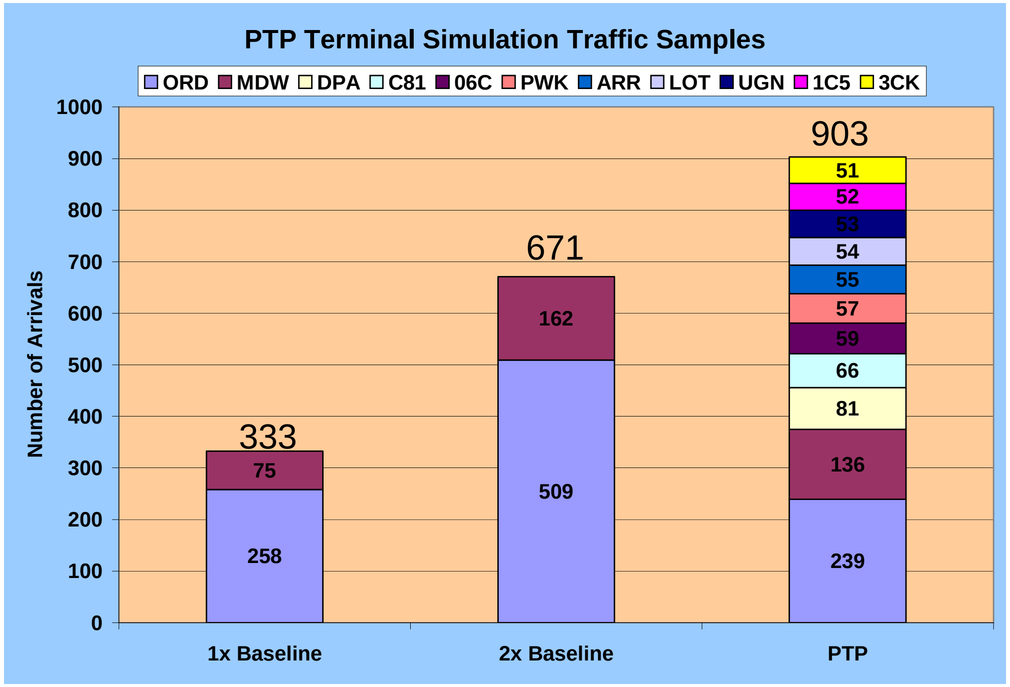
PTP



- **Key Metrics:**
  - **Number of total aircraft-aircraft conflicts**
  - **Level of runway arrival delays**

PTP Phase III Extended Terminal Area Simulation: *Demand Set*

- **Demand Sets:**
  - **1X Baseline**
    - › **3 peak hours of actual May 17, 2002 ORD and MDW arrival traffic**
  - **2X Baseline**
  - **PTP**
    - › **Baseline ORD/MDW arrivals + anchor point-based 9 PTP auxiliary airport arrivals**
    - › **Uses AvDemand Secondary Airport Distribution Routines**
    - › **2.7X Baseline total operations**

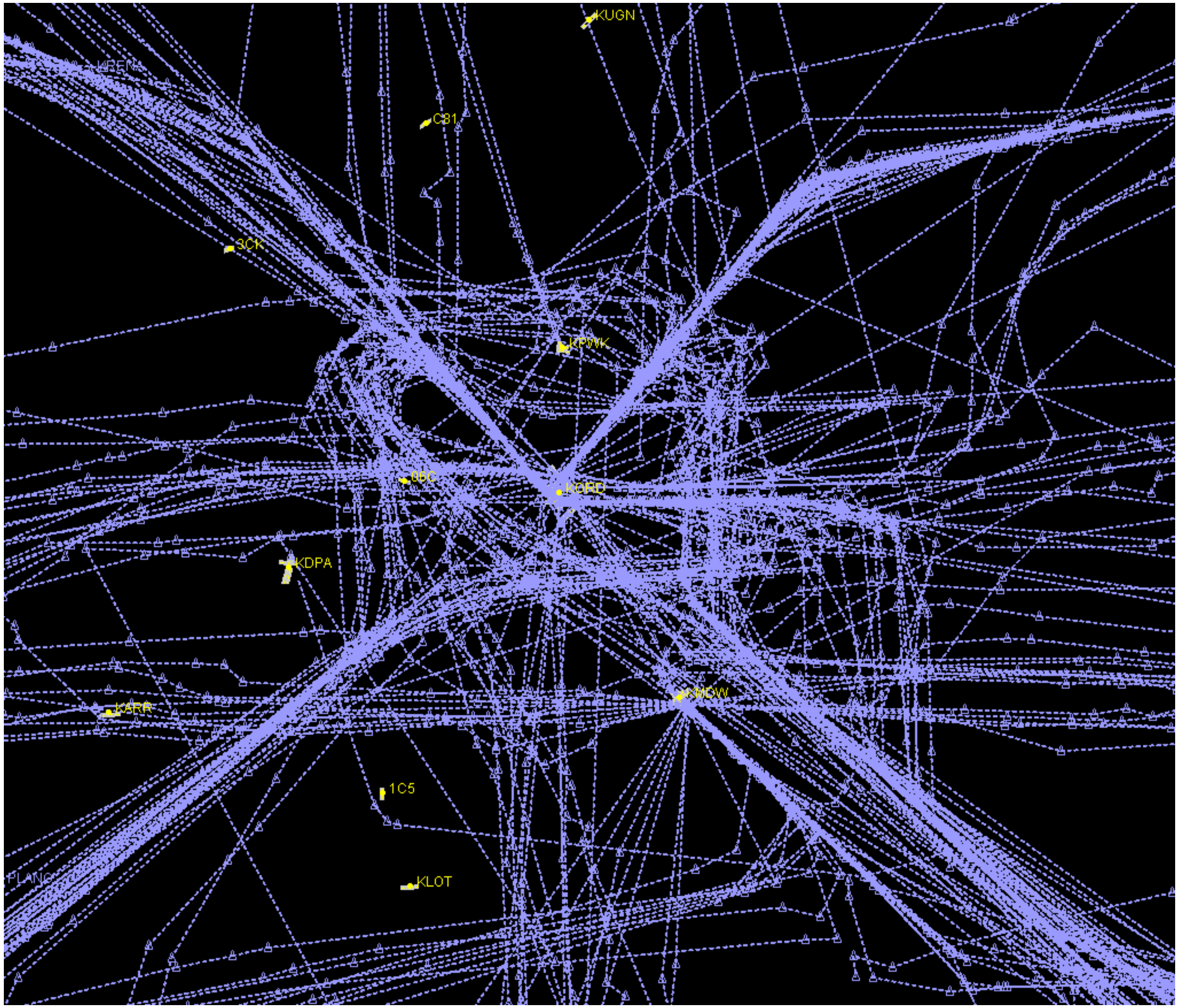


ORD Plan X Configuration

Source: Gehrig, R., Burzych, C., "O'Hare Airport Runway Configurations," Chicago-O'Hare International Airport ATC Guide 9, 2003

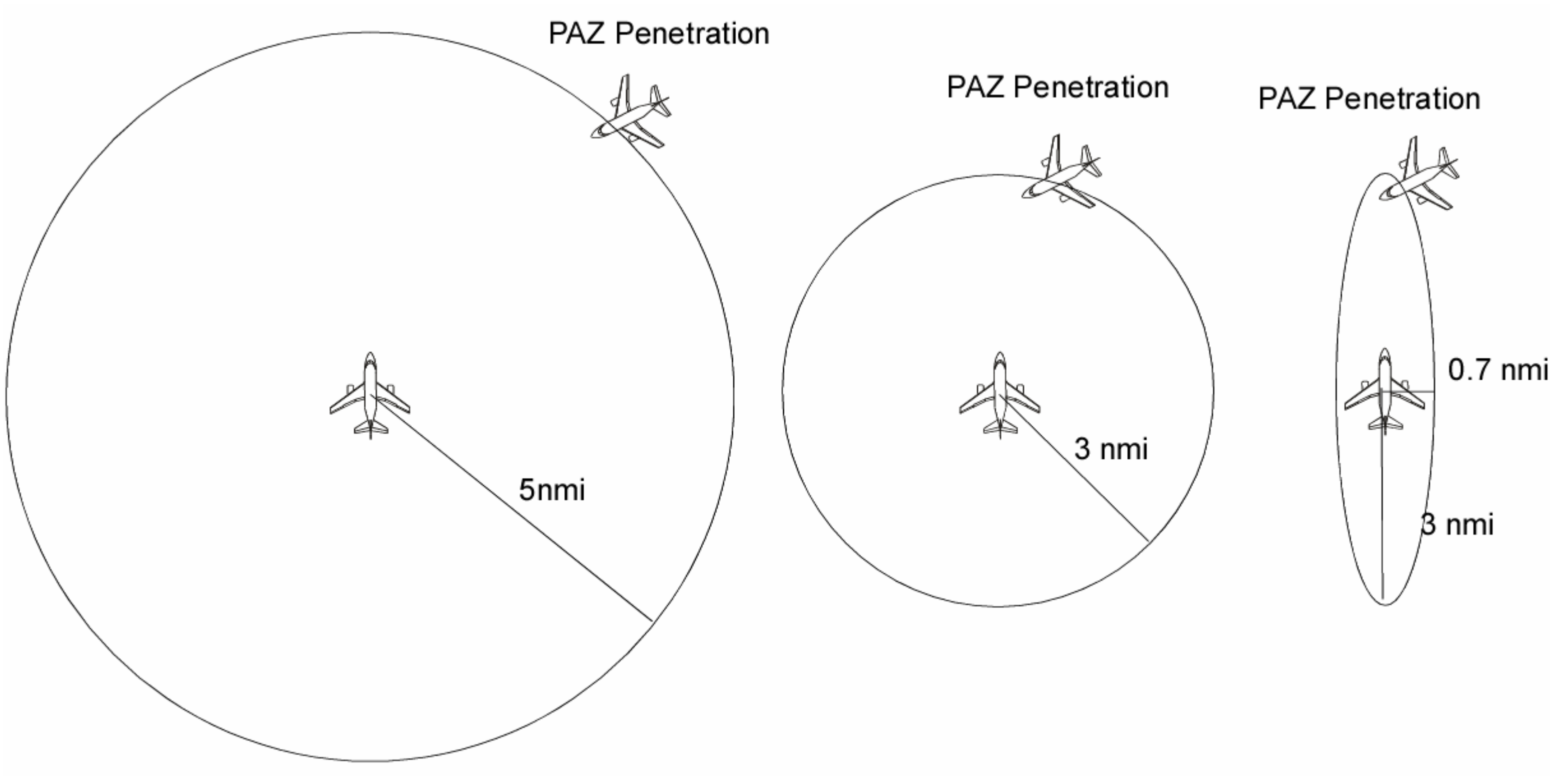
C90 Terminal Airspace Arrivals

- **Based on analysis of March 24, 2004 C90 track data**



PTP Phase III Extended Terminal Area Simulation: *Conflict Definition*

- **Horizontal PAZ:**
  - **5 nmi (x 5 nmi)**
    - **Typical En Route Definition**
  - **3 nmi (x 3 nmi)**
    - **Typical Terminal Definition**
  - **3 nmi x 0.7 nmi**
    - **Future RNAV-based Definition**

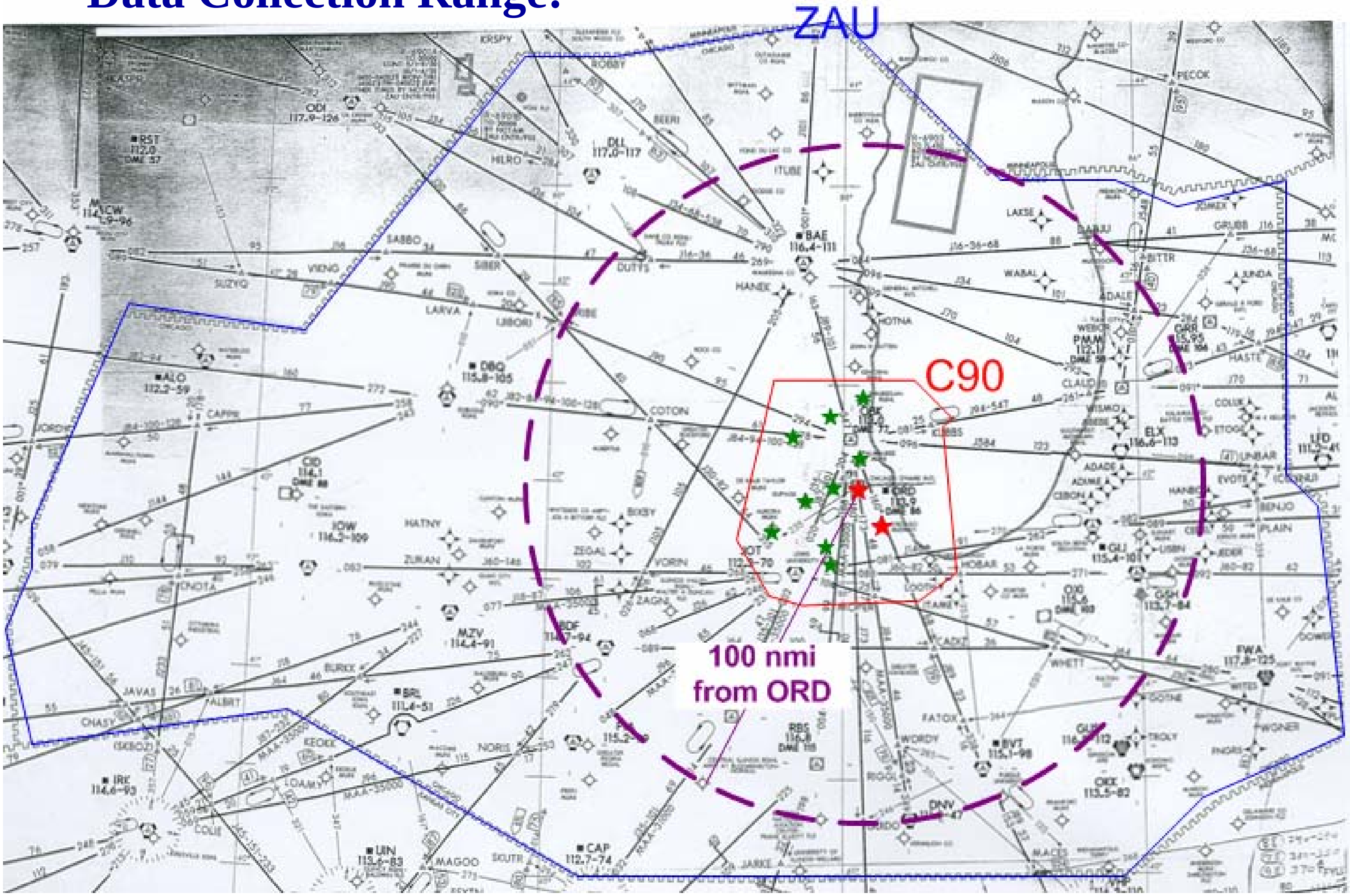


PTP Phase III Extended Terminal Area Simulation: *Simulation Runs*

Run	Dataset	Horizontal PAZ Dimension
1	1X Baseline	5 nmi
2	1X Baseline	3 nmi
3	2X Baseline	5 nmi
4	2X Baseline	3 nmi
5	2X Baseline	3x0.7 nmi
6	PTP	5 nmi
7	PTP	3 nmi
8	PTP	3x0.7 nmi

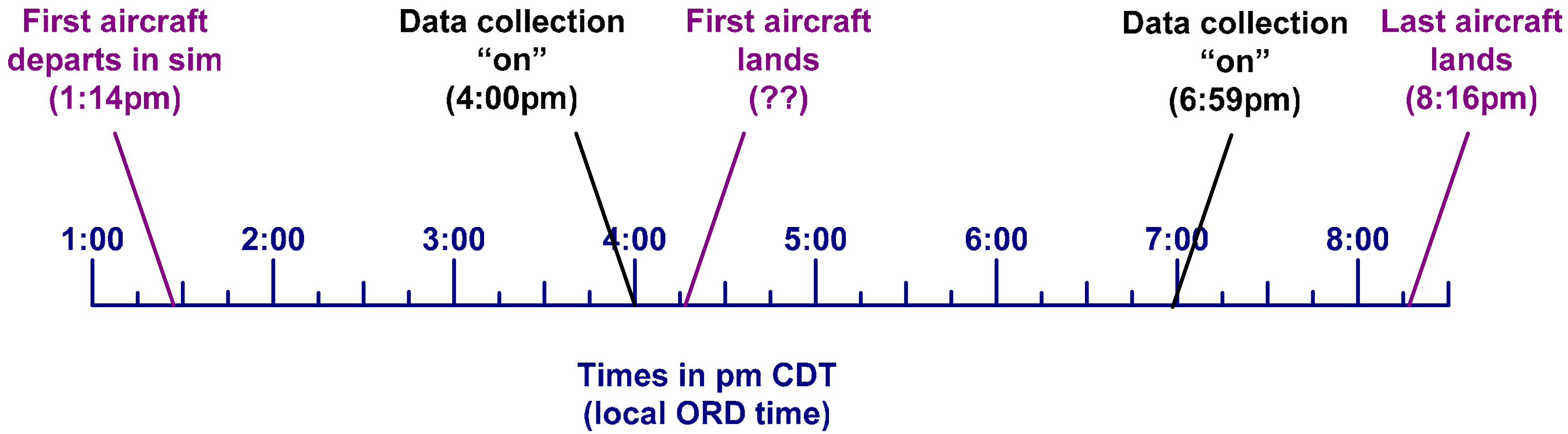
PTP Phase III Extended Terminal Area Simulation: *Data Collection*

- **Data Collection Range:**



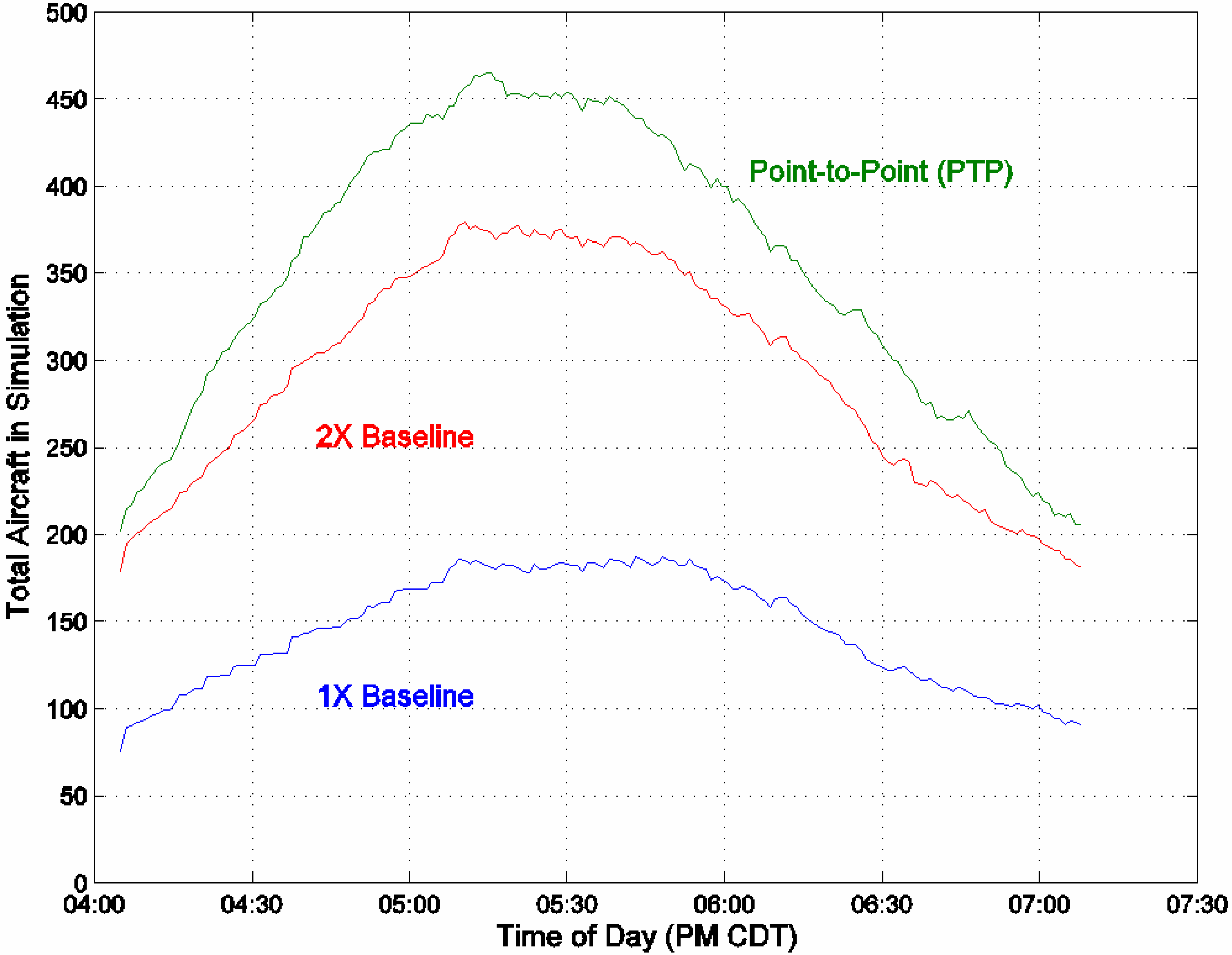
PTP Phase III Extended Terminal Area Simulation: *Experiment Processing*

- **Experiment Timeline:**
  - **Day based on 5/17/02 traffic**



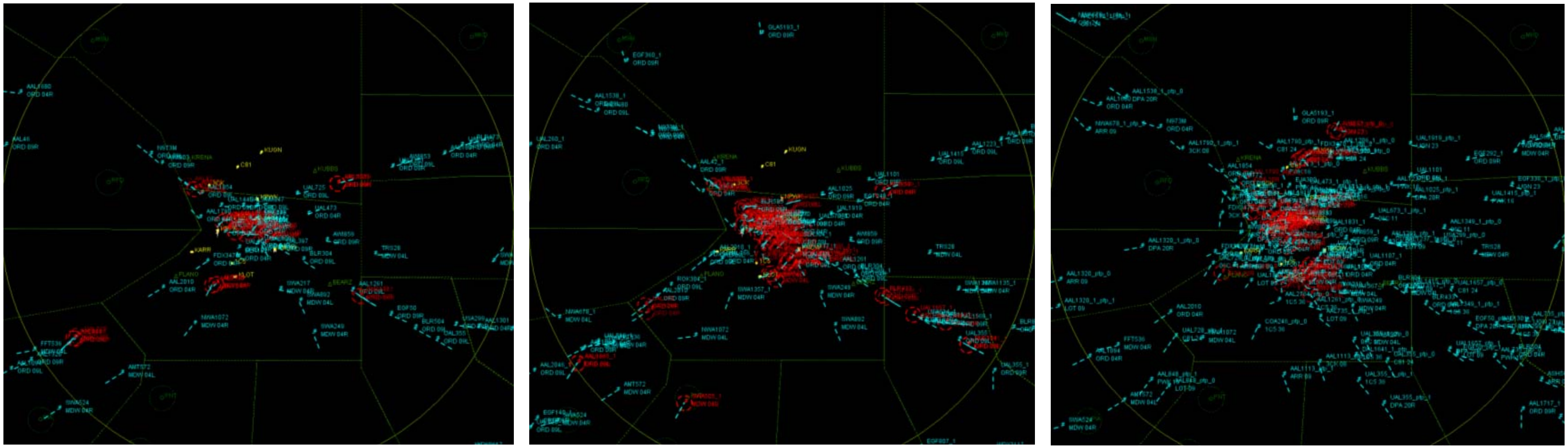
PTP Phase III Extended Terminal Area Simulation: *Results*

- **Traffic Loading (Total Sim) vs. Time:**



PTP Phase III Extended Terminal Area Simulation: *Traffic Situation*

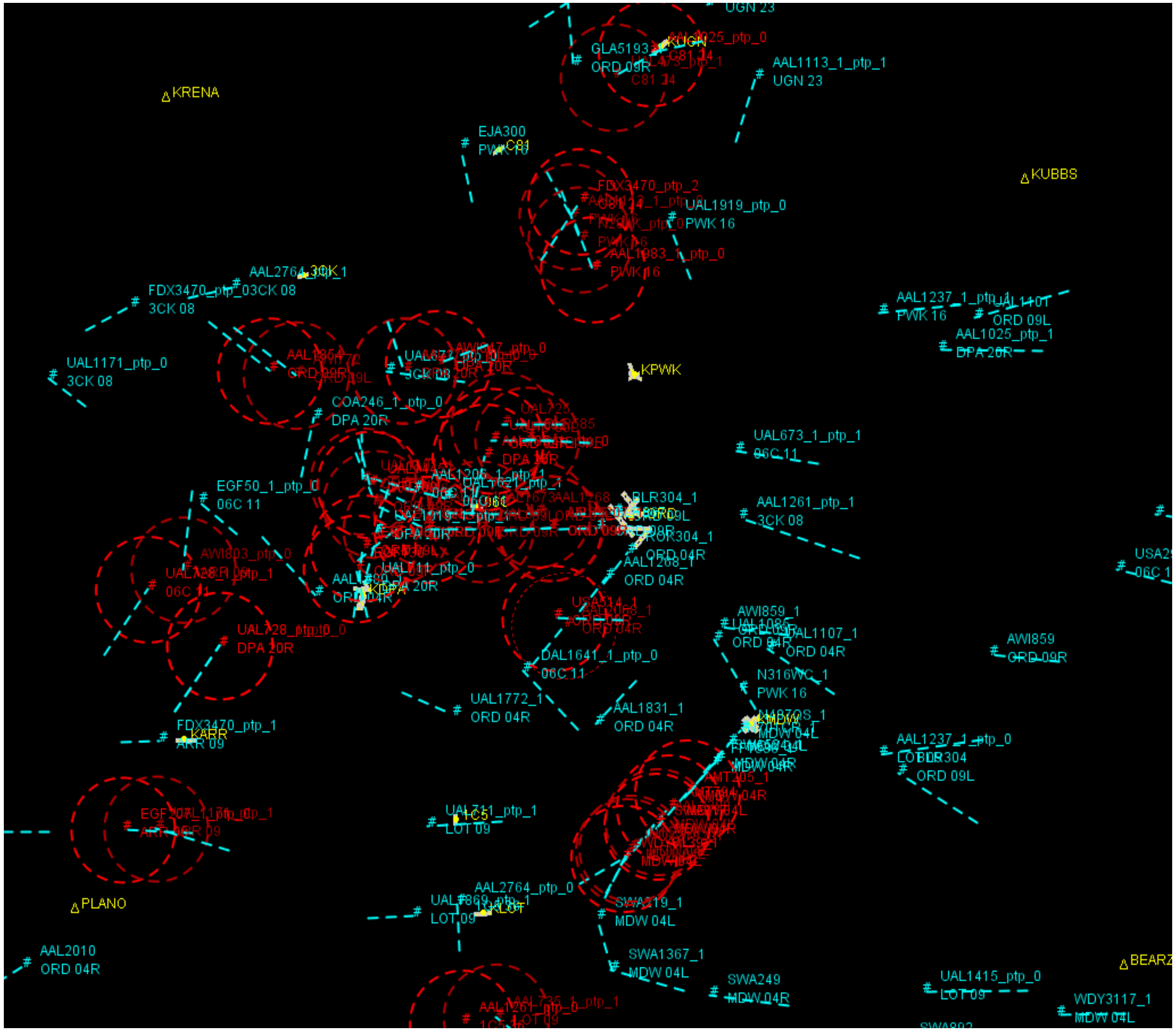
- **Peak traffic loading at 5:53pm CDT *within 100nmi of ORD*:**



1X Baseline *2X Baseline* *PTP*

PTP Phase III Extended Terminal Area Simulation: *Traffic Situation*

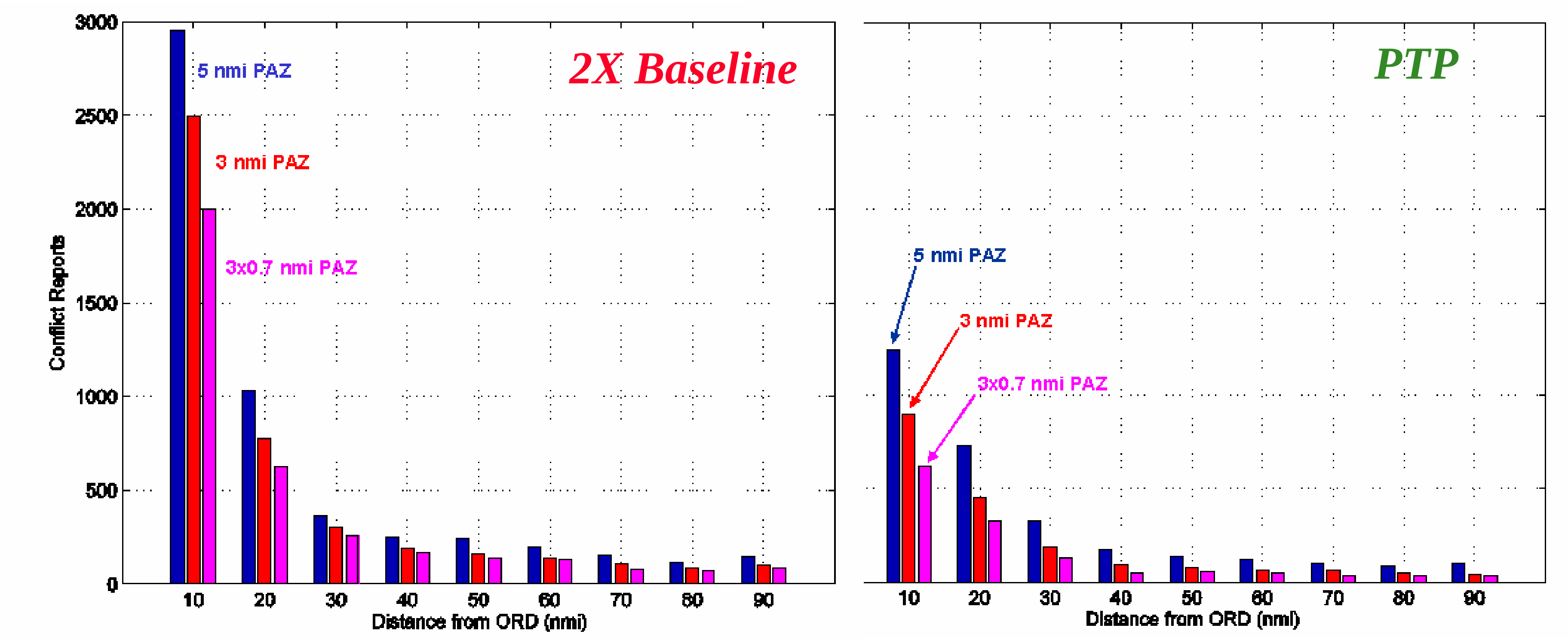
- **Peak traffic loading at 5:53pm CDT *within 30nmi of ORD*:**



2X PTP

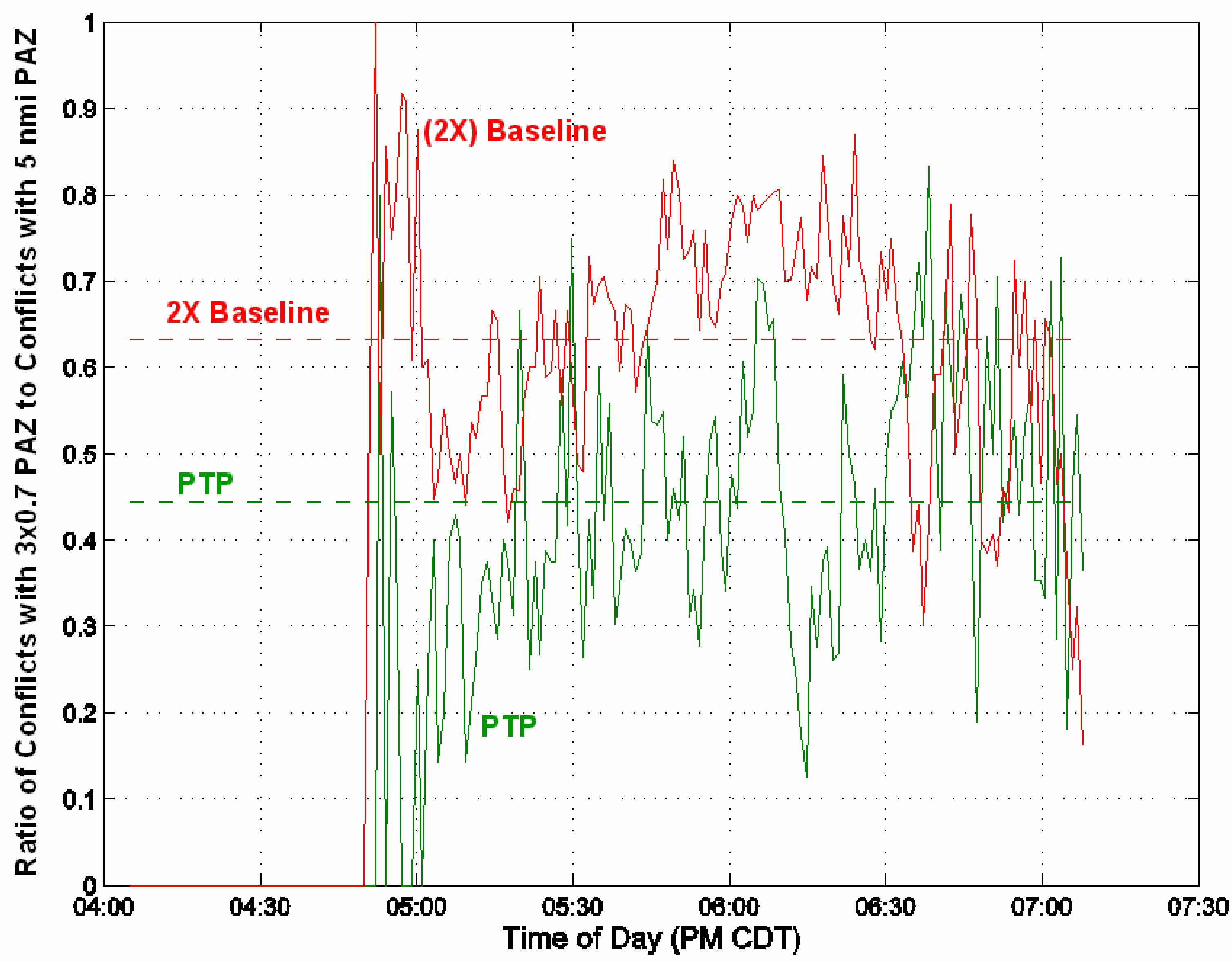
PTP Phase III Extended Terminal Area Simulation: *Results*

- **Conflict Reports as a Function of Distance from ORD:**



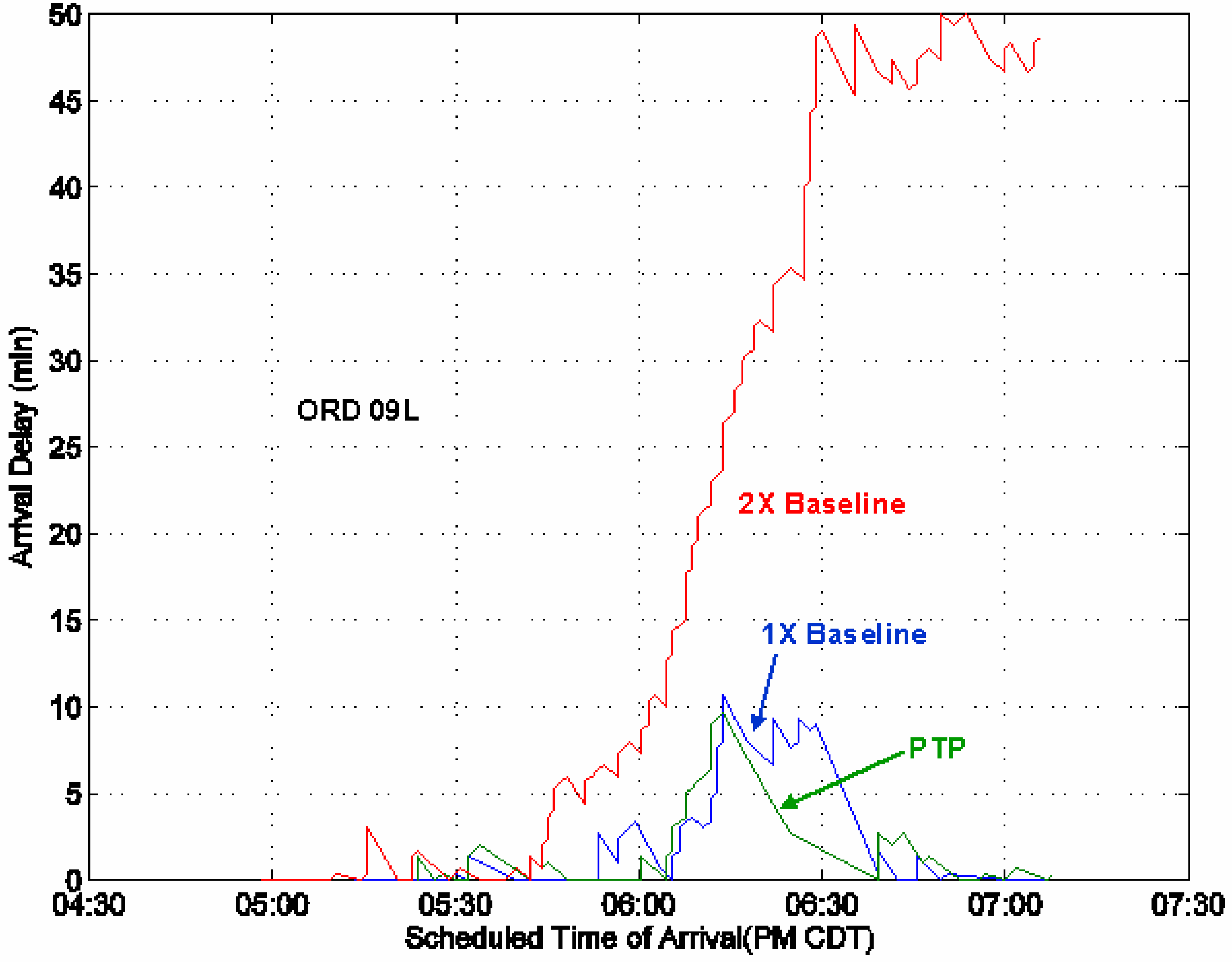
PTP Phase III Extended Terminal Area Simulation: *Results*

- **Ratio of Conflicts with 3x0.7 PAZ to Conflicts with 5x5 PAZ:**



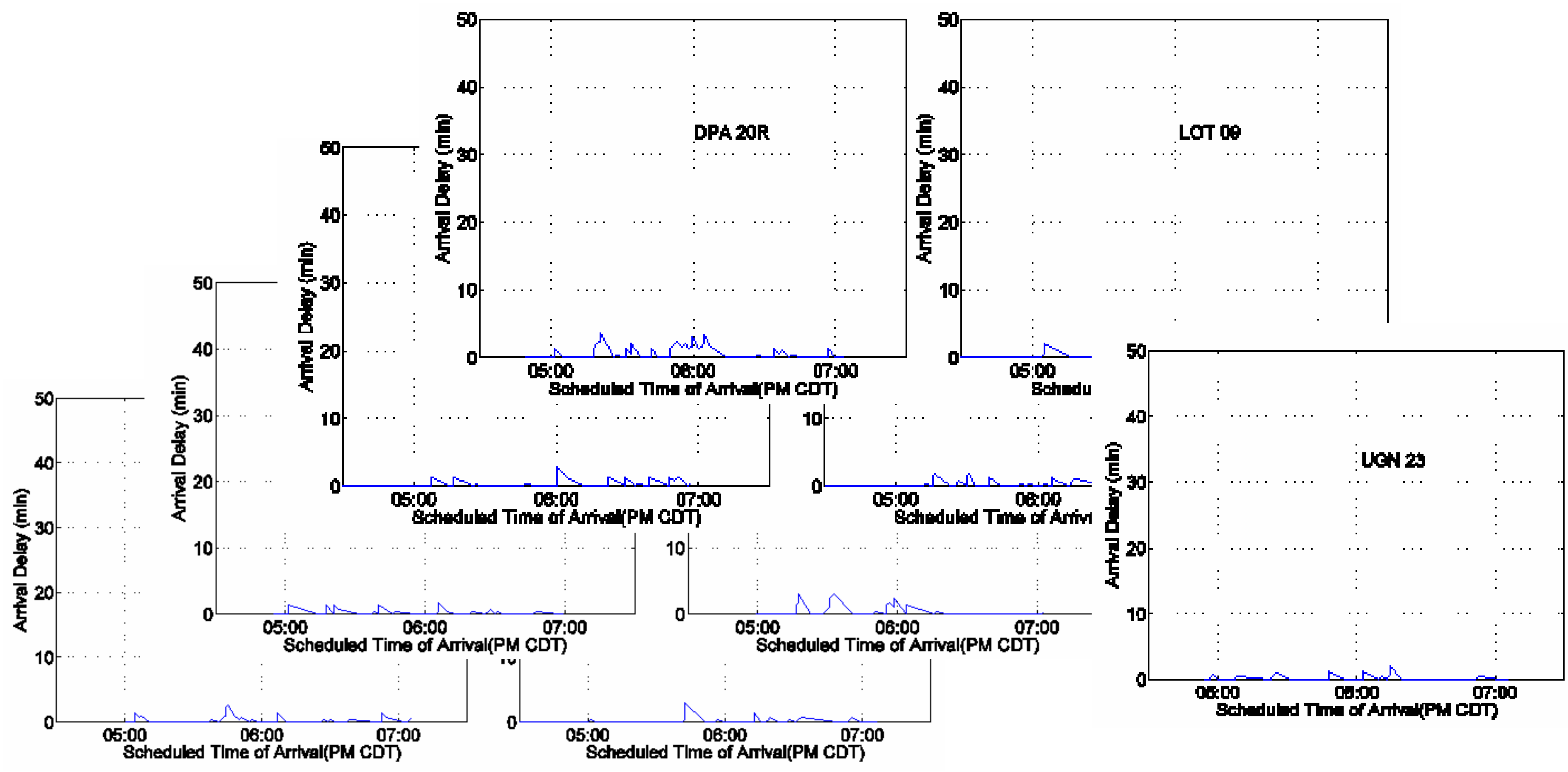
PTP Phase III Extended Terminal Area Simulation: *Results*

- **Typical runway delay results for ORD runways:**



PTP Phase III Extended Terminal Area Simulation: *Results*

- **Runway Delay Results for PTP Runways:**



Future Near-Term Terminal Simulation Enhancements

- Add Departures and Overflights
- Include Atmosphere
- Add More Aircraft Types
- Landing and Takeoff Separation Constraints
- Fine-tune Approach/Departure Paths
- Add Separation Assurance Functions
  - Path Stretching
  - Speed Reduction
  - Holding Pattern
- Add Traffic Flow Management Functions
  - Landing and Takeoff Scheduler
  - Landing and Takeoff Operations Sequencer
  - Runway Balancer
- Improve PAZ Modeling
  - Towards more physics-based approach a la Zhao
- Add Modeling of Other SLIC Concepts

Future Long-Term Terminal Simulation Enhancements

- Focus on Developing Technology Models including:
  - 4D FMS
  - Extended Terminal Area ATM automation for 4D contract negotiation
  - Air-Ground Data link
- Uncertainty Modeling
  - E.g., Navigation, Flight Technical Errors, Surveillance, Wind, Pilot Procedures and Timing
- Performance and Procedure Diffs as a Function of Aircraft Equipage
  - 4D PTP vs. non-4D equipped
- Handle Missed Approaches
- Emulation of Moving Convective Weather Cells and ATC and Aircraft Responses
- Dynamic Multiple Runway Use Configurations
- Support HITL Sims

Self Assessment Questions To Be Addressed

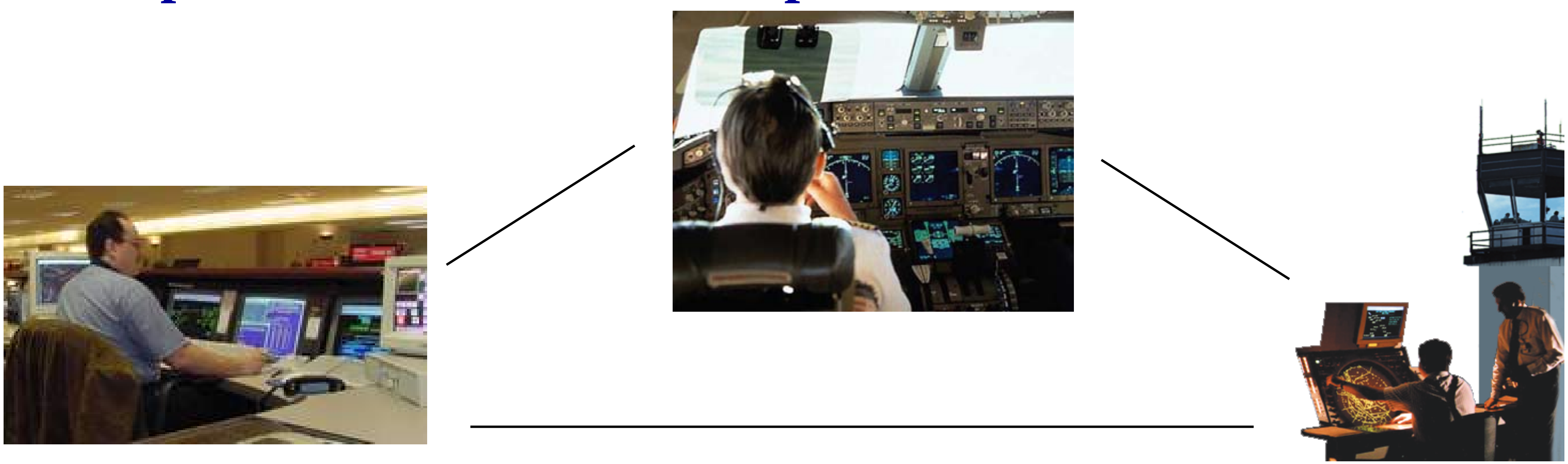
- Is Concept PTP Economically Beneficial?
  - If so, what does the Cost-Benefit Analysis show in terms of benefits and benefit-cost ratio?
  - *Approach:* ACES

- Is Concept PTP Technically Feasible?
  - If so, what are the Technology Requirements?
  - *Approach:* Extended Terminal Simulation

- Is Concept PTP Operationally Viable?
  - If so, what are the Human Performance Requirements?
  - *Approach:* Questionnaire, Requirements Analysis, SME Interviews

Issue of Operational Feasibility

- **Question:** If we provide a suite of new PTP technologies and procedures to the air traffic controllers, pilots, and dispatchers, can they effectively carry out their jobs in safely enabling future increases in NAS aircraft flight operations?
- **Hypothesis:** We think so, by making sure that the human element is properly addressed in the design and ultimate implementation of the concept



- **We need to flesh out the human performance issues to validate this hypothesis**

Phase 3 PTP Human Factors Assessments

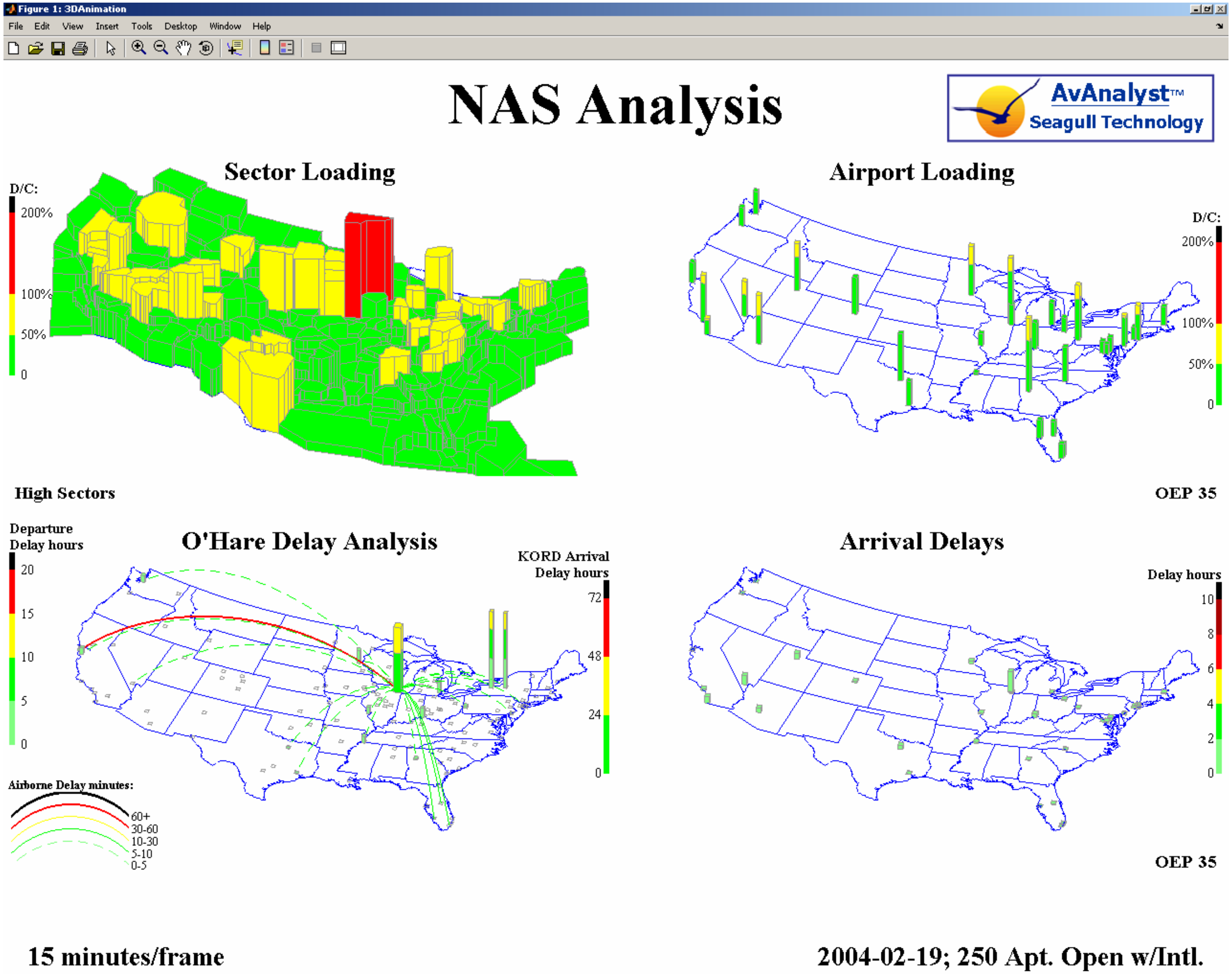
- Obtained detailed ATC SME feedback on emerging Concept PTP issues including:
  - Mixed Equipage
  - Concept PTP Transition
  - Responsibility
  - Airspace Issues
- Future steps: Fast-time human performance model, tool prototyping, and real-time assessments are critical to further refinement of human factors issues
  - Feasibility of equipped user procedure preferences
    - E.g., “unequipped aircraft must move” conflict resolution, segregated self-separation airspace
  - Feasibility of controllers ability to handle less-structured, higher levels of traffic with reduced levels of traffic state and intent uncertainty leveraging improved CNS and ATM decision support tools

Lessons Learned

- Enhancing NAS capacity at non-choke points may not only not solve the future NAS problem, but may make the problem worse
  - It is critical that the VAMS concept blending fully understand where the future NAS chokepoints are make blending decisions based on this knowledge
- A “bad weather” day of the past may not be so bad in the future
- ACES has output data that can be converted into a wide range of useful output metrics: costs, passengers, etc.,
  - However, higher accuracy for some metrics requires use of both the input FDS file data and ACES output data
    - ACES output data has imbedded aircraft types that are lower resolution than the aircraft types in the FDS file
- ACES Build 2.0.3 removed significant numbers of flights from the input demand sets resulting in underprediction of NAS delays
  - ACES Build 3 should fix flight demand dropouts and enable international flight modeling

Lessons Learned

- Output data conversions require significant effort
  - Development of ACES post-processing tool(s) is recommended



Issues/Challenges

- ACES ability to model realistic weather days
  - Need to perform detailed validation and ACES model enhancements driven by validation results
- Need to quantify PTP-specific airspace capacity improvements
  - Key issue: airspace capacity with mixed managed and 4D-capable PTP aircraft
- Had difficulty getting access to NAS SMEs and operational data to better understand PTP transition issues

PTP Self-Assessment Results Summary

- **Economic Feasibility:**
  - **Generated NAS-wide Demands for 1X, 2015, 2020, and 2X traffic levels**
  - **Studied two ways to interpret PTP cost-benefit and both show significant economic promise**
  - **Furthered Chicago Metro study & identified optimal PTP D/C ratio**
  - **Conducted NAS-wide PTP benefits study which showed that:**
    - **Despite significant potential PTP airport capacity improvements, airspace capacity restrictions minimized potential delay benefits**
      - in both good and bad weather cases
    - **Combining PTP airports and 3X en route airspace improvements provided 2X passenger throughput at very tolerable delay level**
- **Technical Feasibility:**
  - **Constructed a detailed Extended Terminal Airspace Model**
  - **Initial Chicago Area results suggest fewer significantly fewer arrival conflicts with PTP routings and PAZs despite higher traffic levels**
- **Operational Feasibility:**
  - **Many PTP human factors issues have been identified**
  - **Need to assess controller ability to feasibly handle increased traffic with less structure using 4D trajectory-based DSTs**
- ***Concept PTP Design and Evaluation Work is On-going***

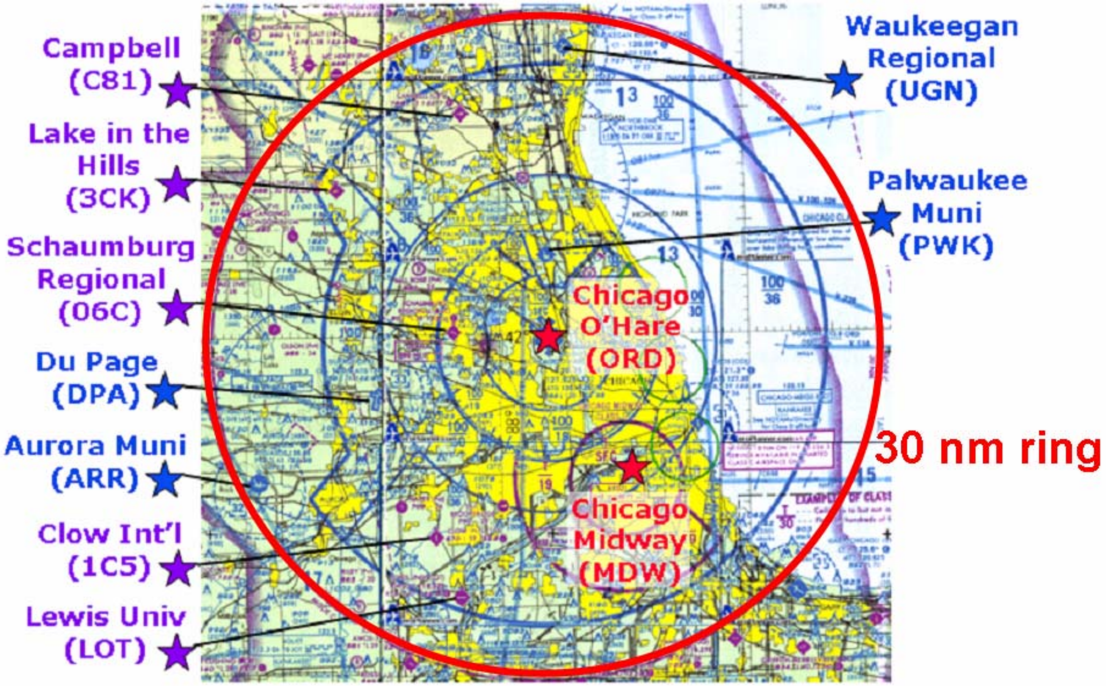
Background Slides

Outline

- Assessment Questions
- Approach/Metrics/Interim Results
  - ACES Assessments
    - Chicago Regional Benefit-Cost
    - Chicago Regional Sensitivity Analysis
    - NAS-wide Demand Generation
    - NAS-wide Benefits
  - Extended Terminal Simulation
  - Human Factors
- Lessons Learned
- Issues/Challenges

Approach:
System Generation

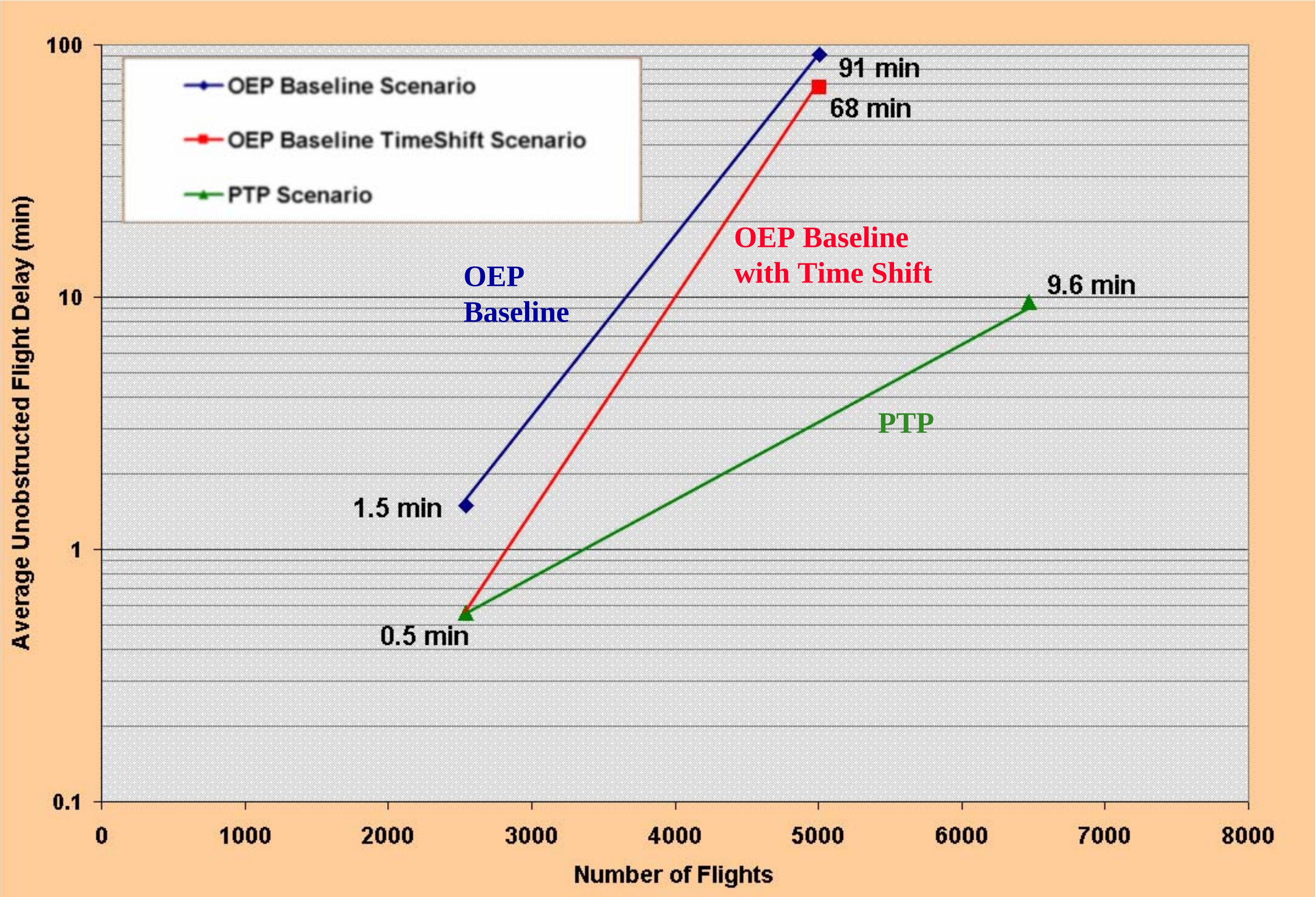
Baseline System



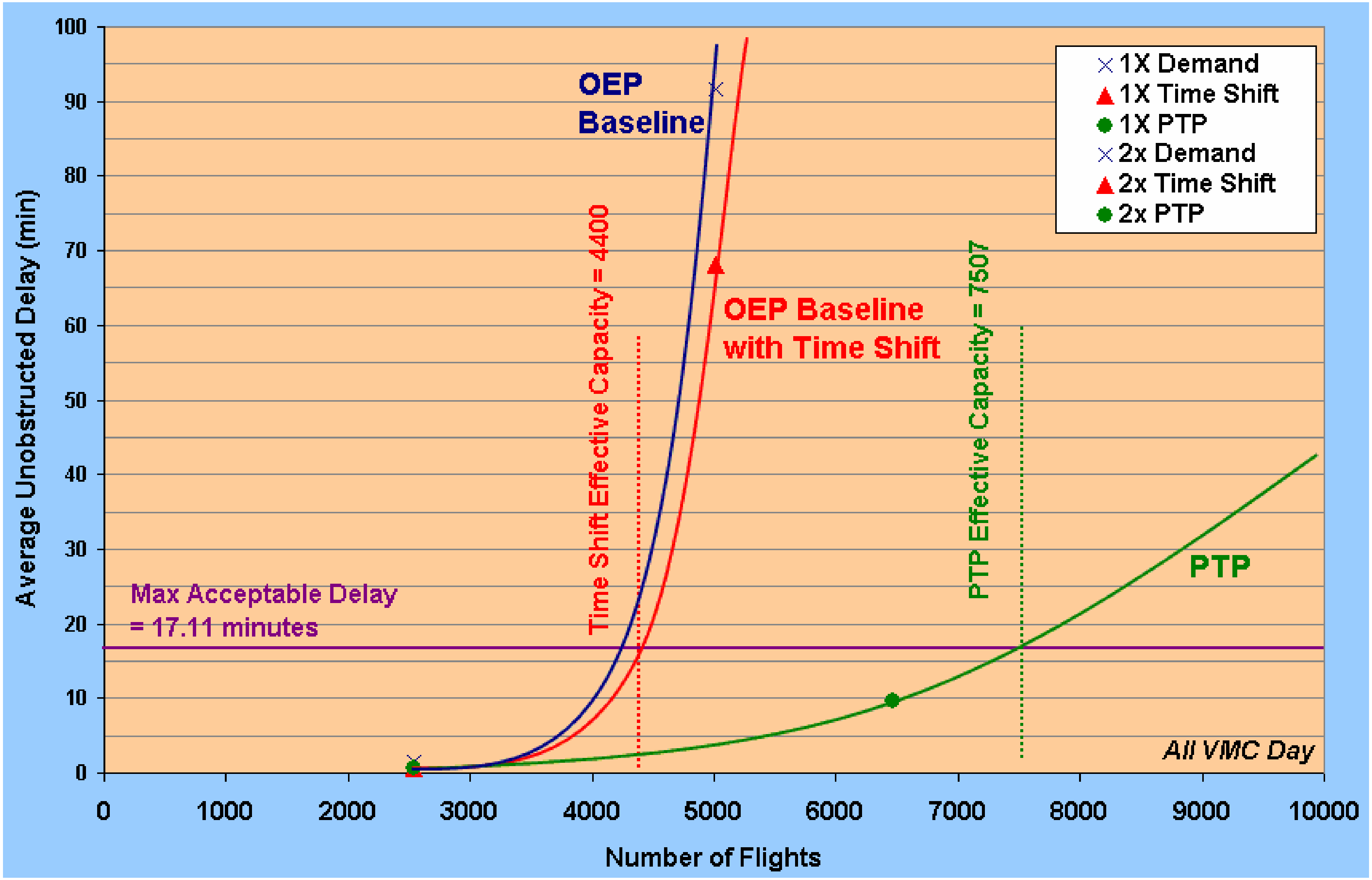
Future Concept PTP System

Chicago Metro Area Benefit Results

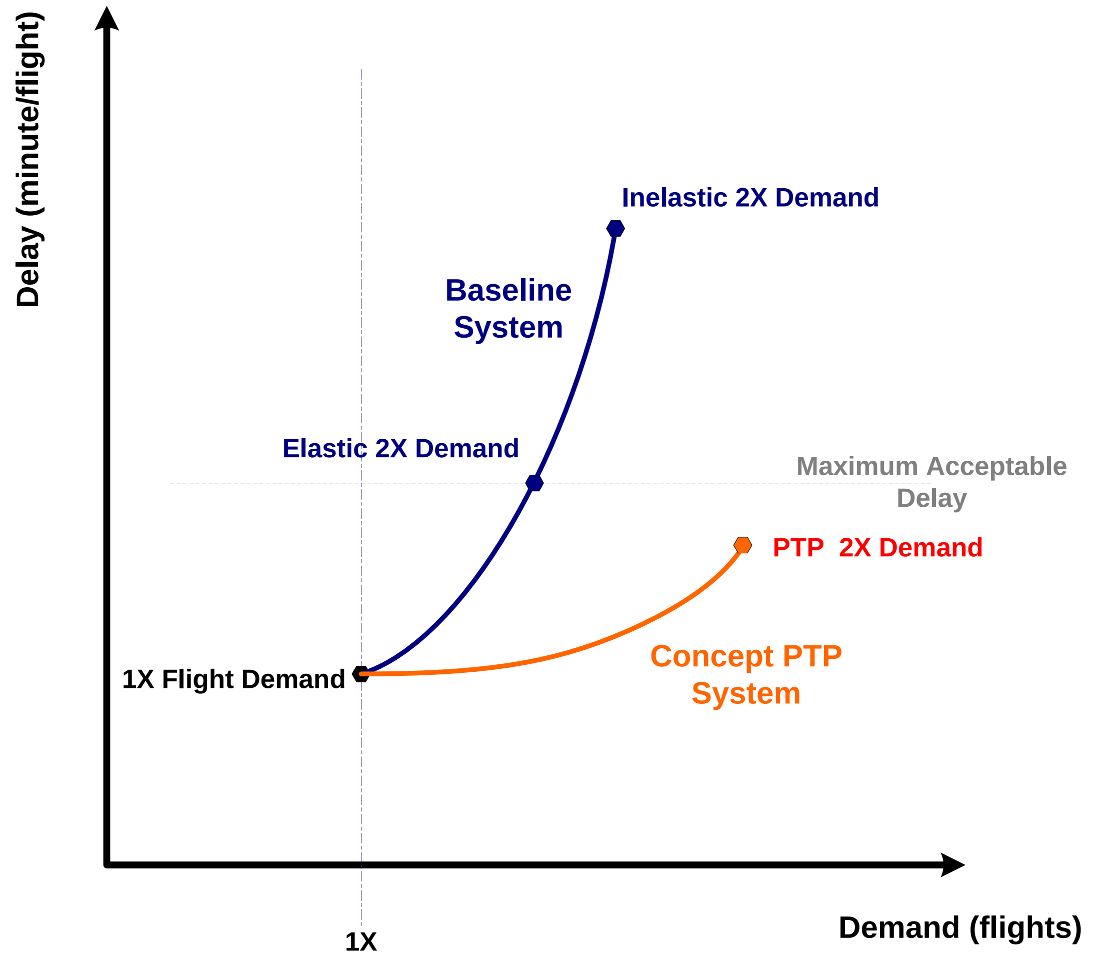
- **Using:**
  - Chicago Metro Area Demand and Capacity Levels
  - ACES (incl. en route queuing, CD&R, no AOC cancellations)
  - VMC all day
  - Delays based on unobstructed flight times, not schedule data



Effective Capacity Estimation Assuming Exponential Demand-Delay Relationship



Benefit-Cost Analysis



$$EconomicBenefits = Revenue_{ConceptX} - VarDOC_{ConceptX} - FxdDOC_{ConceptX} - NASCosts_{ConceptX} - (Revenue_{BaseSys} - VarDOC_{BaseSys} - FxdDOC_{BaseSys} - NASCosts_{BaseSys})$$

$$EconomicCosts = Cost_{ConceptX} - Cost_{BaseSys}$$

Chicago Metro Area Benefit-Cost Results

Economic Value	Inelastic Demand Value in 2003$	Elastic Demand Value in 2003$
Baseline System Daily Revenue		$29,242,125
Baseline System Daily Variable Direct Operating Costs	$40,978,348	$20,535,794
Baseline System Daily Fixed Direct Operating Costs	$8,789,611	$7,553,404
Concept PTP Daily Revenue		$36,555,708
Concept PTP Daily Variable Direct Operating Costs	$23,103,853	$23,103,853
Concept PTP Daily Fixed Direct Operating Costs	$12,517,665	$12,517,665
Concept PTP Daily Marginal NAS Infrastructure Costs	$19,139	$19,139
Concept PTP Daily Economic Benefits	$14,127,302	-$237,876
Concept PTP Daily Economic Costs	$19,139	$19,139
Concept PTP Daily Economic Benefit-to-Cost Ratio	738	-12.4

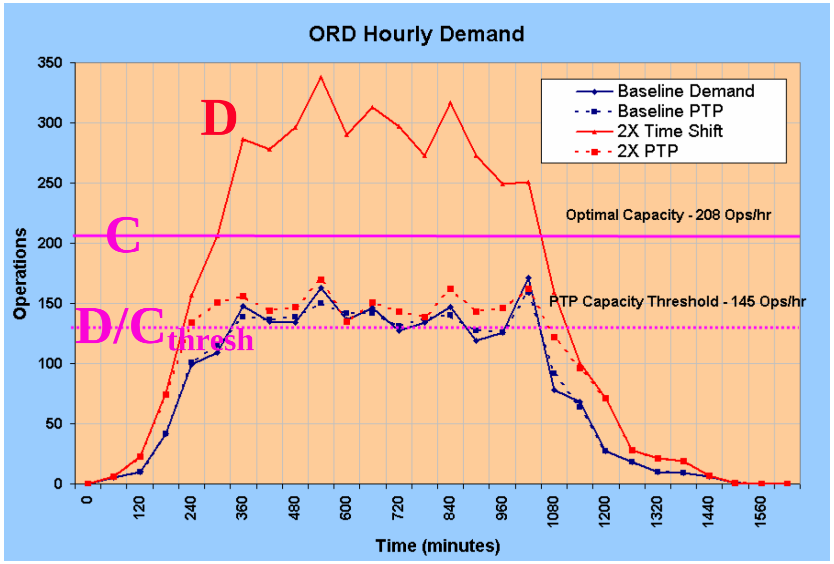
- **In the Elastic Demand case:**
  - **Increasing Passenger Revenue (i.e., Ticket Prices) by $1/passenger, yields a Benefit-to-Cost Ratio of 8.6**

Outline

- Assessment Questions
- Approach/Metrics/Interim Results
  - ACES Assessments
    - Chicago Regional Benefit-Cost
    - Chicago Regional Sensitivity Analysis
    - NAS-wide Demand Generation
    - NAS-wide Benefits
  - Extended Terminal Simulation
  - Human Factors
- Lessons Learned
- Issues/Challenges

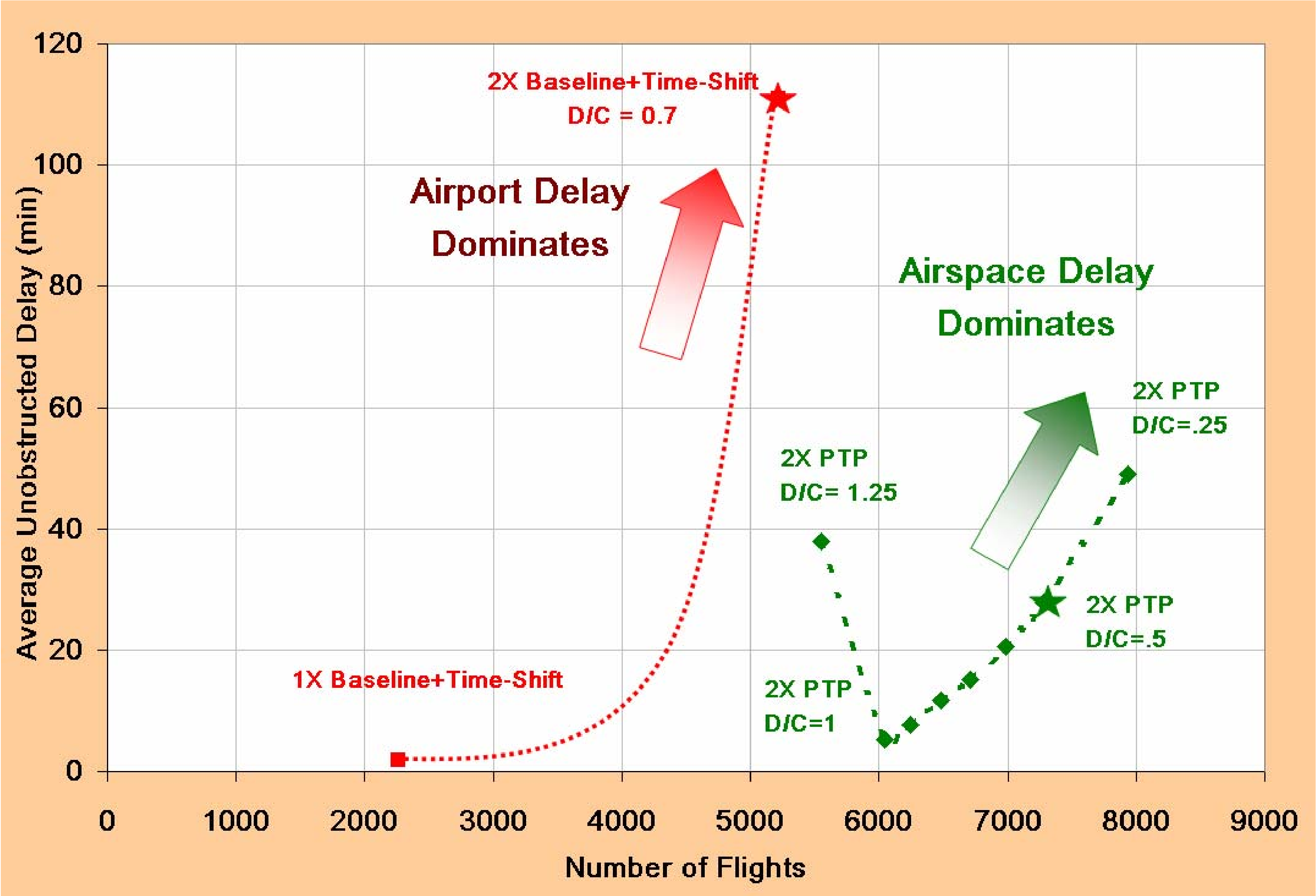
Chicago PTP Benefits as a Function of PTP Distribution Criteria

- **Key PTP Demand Distribution Criteria:**
  - **15 min Max Hub Airport Demand-to-Capacity Threshold**
    - **When Demand is High Enough such that D/C > Max D/C Threshold, Flights Are Distributed to PTP Auxiliary Airports**
  - **Original Assumption: 70%**

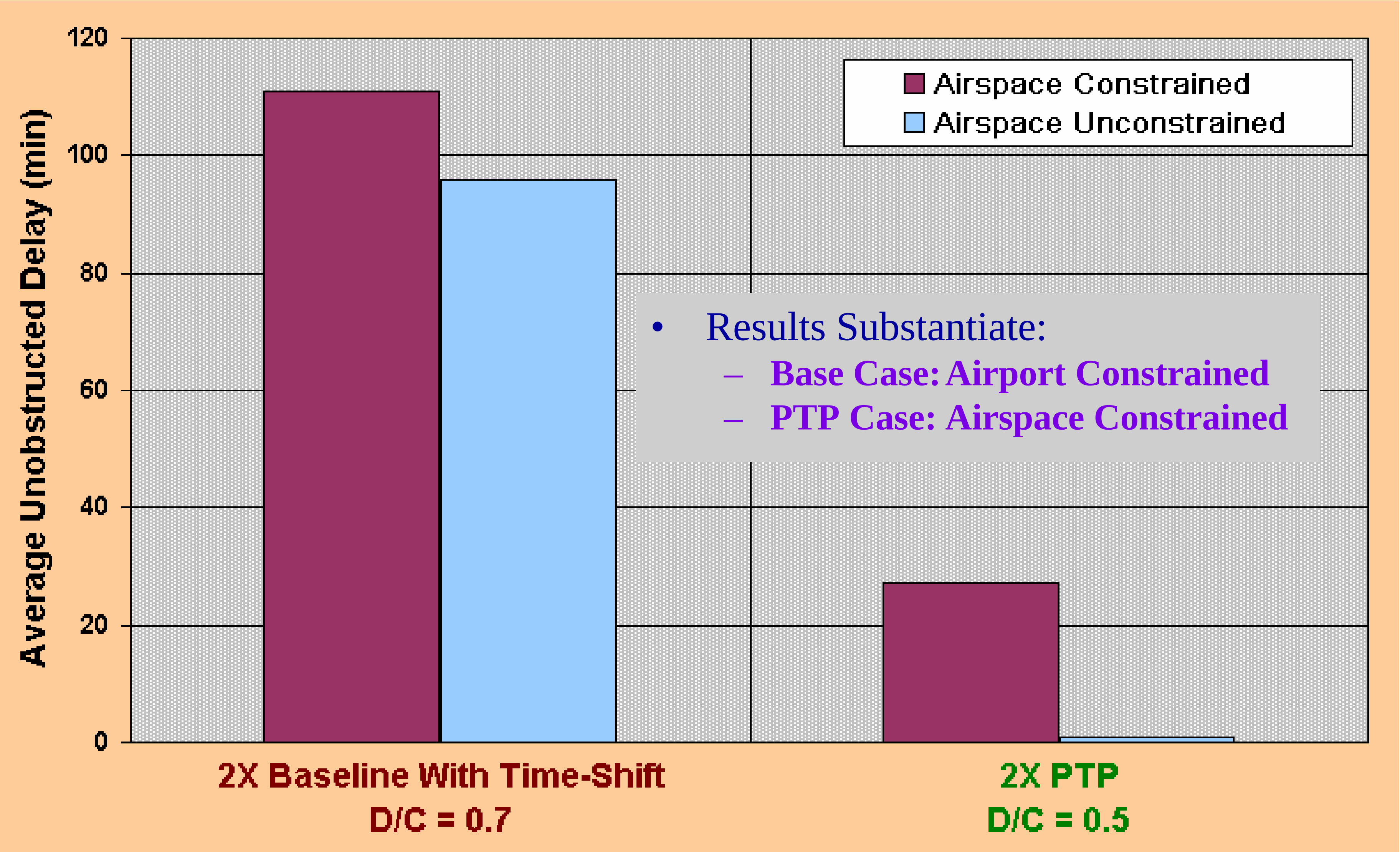


    - **Likely Underutilizing Available Capacity**
    - **Historically, 65% begins the delay "knee in the curve" (ref: Donohue)**
      - Delay Rise is a function of Demand Peakiness
  - **Conducted Sensitivity Study to Determine Optimal D/C Threshold for Minimum Average Delay**

Chicago PTP Benefits as a Function of PTP Distribution Criteria



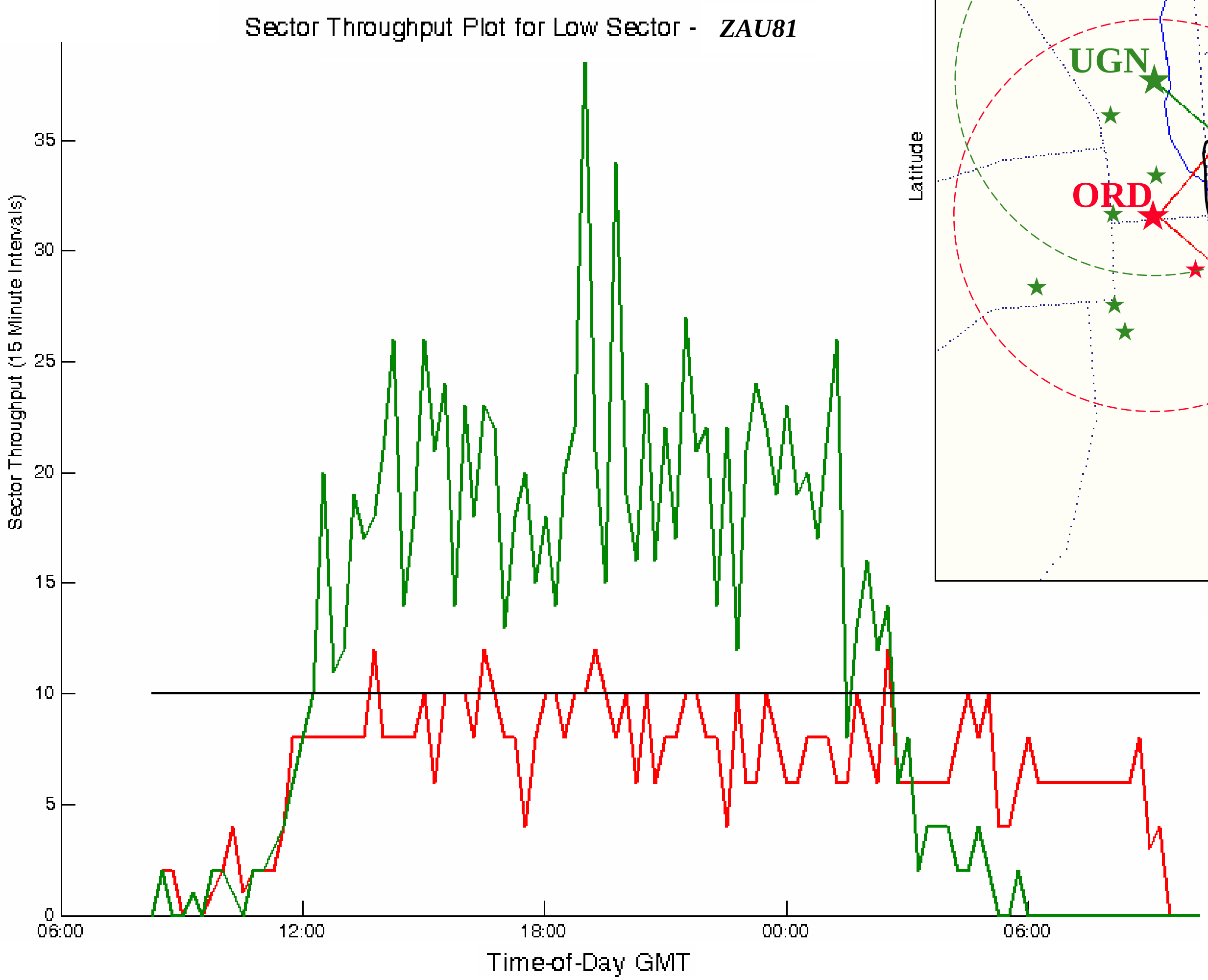
Chicago Baseline vs. PTP Delay Causes

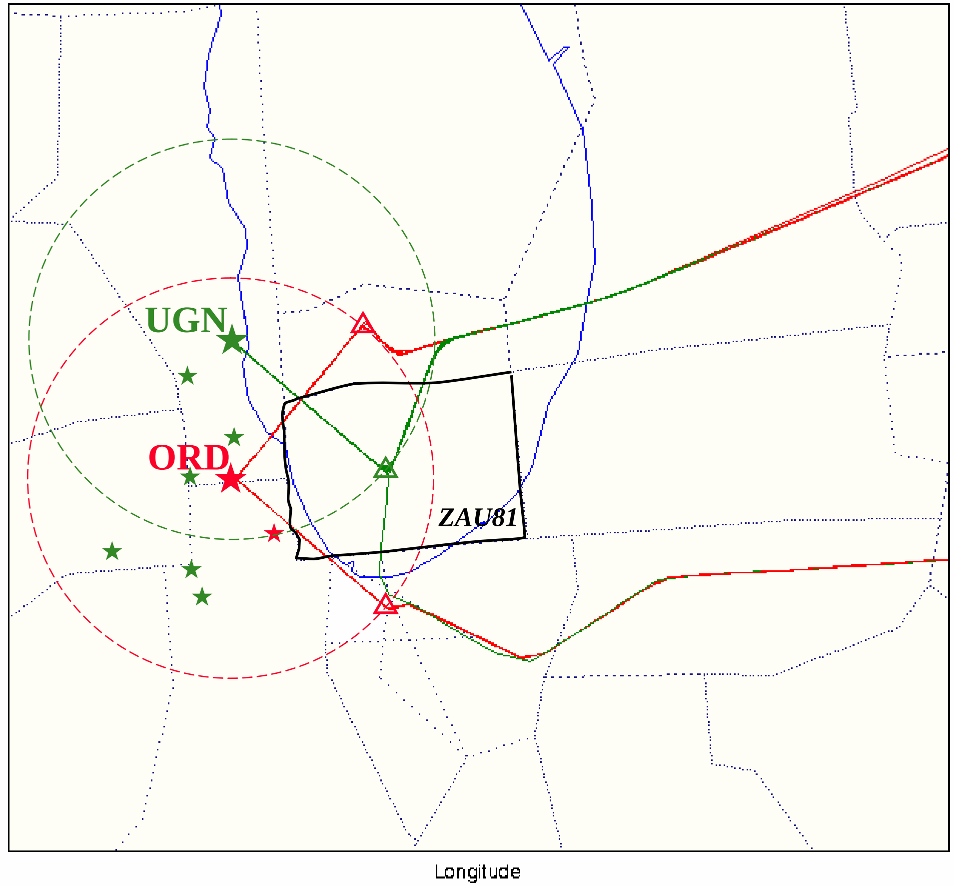


- Results Substantiate:
  - Base Case: Airport Constrained
  - PTP Case: Airspace Constrained

Chicago PTP Airspace Delay Phenomena

- Sector Congestion Increases Under PTP due to Higher Traffic Level
  - Some effect due to ACES 2.03





Future Demand Set Generation

Seagull Technology's AvDemand Demand Generation Tool is used to create future demand sets. The demand set generation process consists of three steps, frequency determination, schedule generation, and time-shifting (due to airport capacity limitations). For the PTP demand sets, a fourth step is also required.

- **Frequency Determination**
  - **The Fratar algorithm is used to model *heterogeneous* airport growth. Each airport's growth rate is the ratio of the number of airport operations based on TAF data for the future year (e.g. 2015) and the baseline year (e.g. 2002).**
- **Schedule Distribution**
  - **The original flights in the 250 airport set will have their gate departure times preserved, while newly generated flights are distributed uniformly between the first and last scheduled gate departure time of the original flights.**
- **Time-Shifting**
  - **Once the schedule is determined, the airport capacity limitation is used to shift arrivals/departures from congested 15-minute time windows to nearby time windows that have capacity to accept flights. The airport capacity limitation is based on the OEP airport capacity for the major airports, and the AC150/5060-5 capacity for the remaining airports.**
- **PTP Flight Diversion**
  - **High frequency flights from a congested airport to a nearby PTP airport. If necessary, additional flights are created using PTP fleet mix (100 seat aircraft). 1,000 nm flight range limitation is imposed.**

NAS-wide Demand Generation: *Converting ETMS to ACES FDS Input*

- **Determine scheduled gate departure time**
  - **Use either:**
    - **FS_DEPT_TIME for scheduled flights, or**
    - **(FZ_ETD – Unobstructed Airport Taxi-Out Time) for unscheduled flights**
- **Convert gate departure times**
  - **Gate departure time in ACES is represented in minutes after a pre-determined reference time**
- **Exclude flight records missing critical data elements**
  - **Aircraft type, departure airport, arrival airport, cruise altitude, cruise speed, waypoint list**
- **Delete duplicate flights**
  - **If a flight has identical airline ID (e.g. UAL123), departure airport, and arrival airport, as another flight.**

VAMS Future Demand Sets

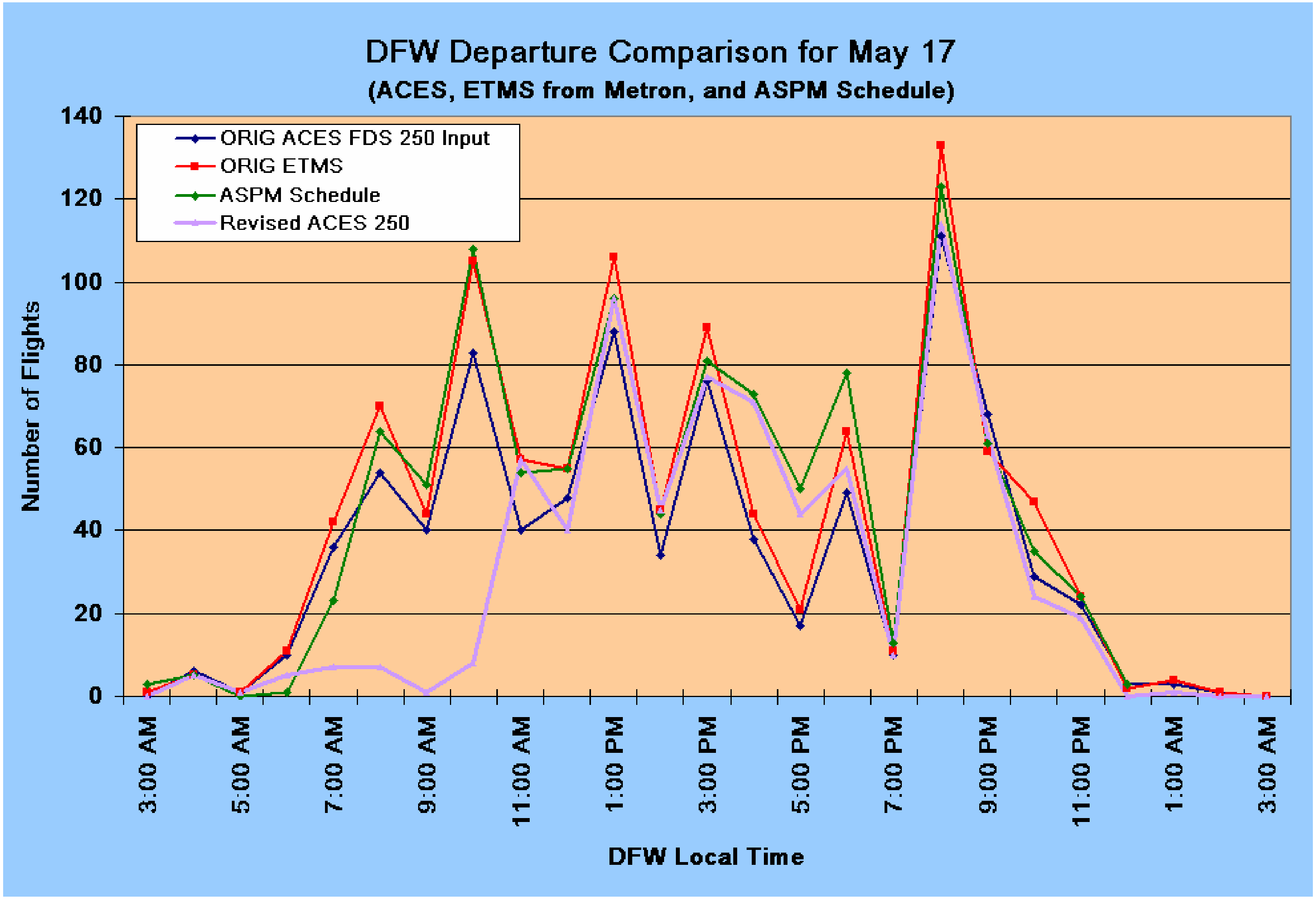
Future demand sets are created from the May 17, 2002 CONUS Top 250 Airports FLTGEN demand set.

- **TAF 2015 – May 17, 2002 CONUS Top 250 Airports FLTGEN Demand**
  - **TAF 2015 flight demand is constructed based on the ratio of TAF 2015 ops to TAF 2002 ops. The resulting TAF 2015 demand set contains 37,257 flights.**
- **TAF 2020 - May 17, 2002 CONUS Top 250 Airports FLTGEN Demand**
  - **TAF 2020 flight demand is constructed based on the same approach as the TAF 2015 flight demand. The only difference is that the growth rate is based on the airport operations ratio between 2020 and 2002 TAF data. The resulting demand set contains 40,540 flights.**
- **2X - May 17, 2002 CONUS Top 250 Airports FLTGEN Demand**
  - **The 2X flight demand set is constructed using an overall target growth of 2x with heterogeneous airport growth based on TAF data. Each airport's growth rate is the airport operations ratio between 2020 and 2002 TAF data. The resulting demand set contains 59,353 flights.**

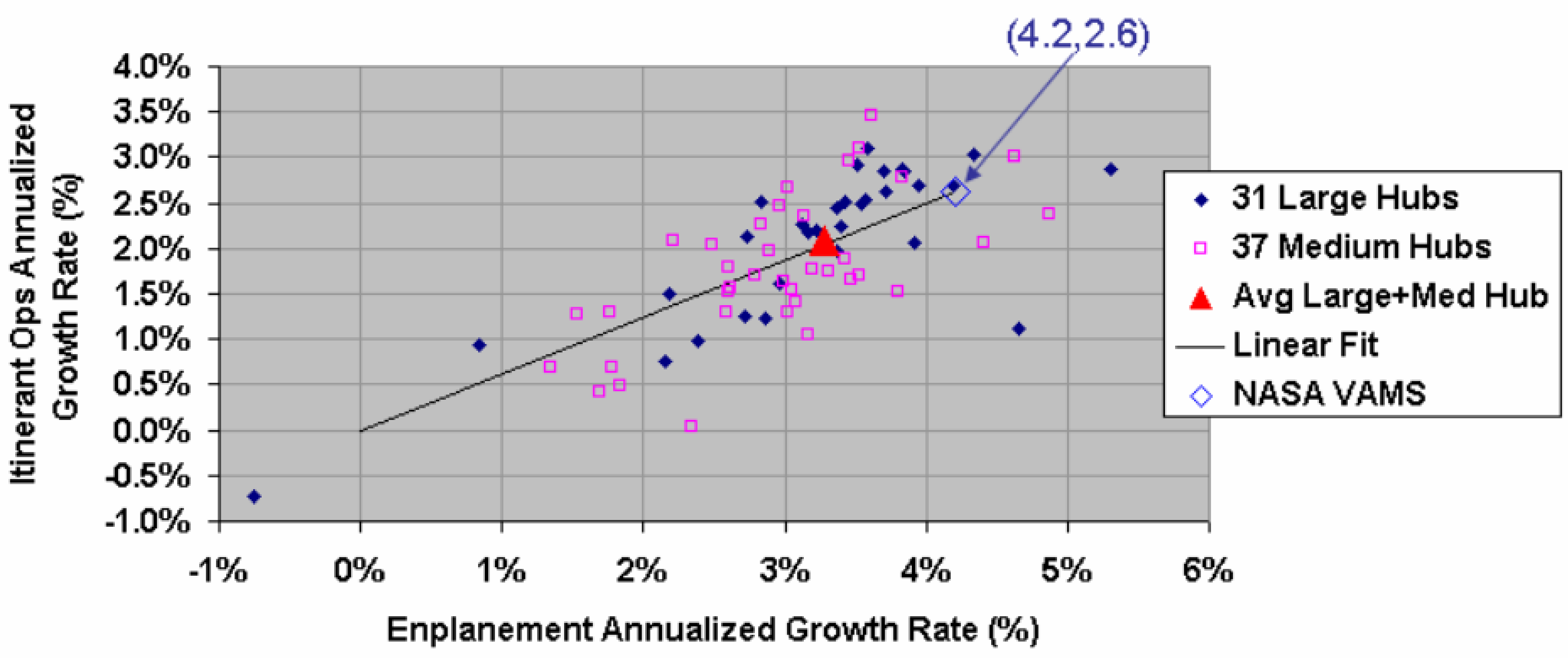
NAS-Wide Demand Generation Procedure

- **Frequency Determination**
  - **Uses Fratar algorithm**
  - ***Heterogeneous* airport growth for TAF 2015 and 2020**
  - ***Overall target growth of 2x with heterogeneous airport growth* for the 2X demand scenario**
- **Schedule Distribution**
  - **Uniformly distribute newly created city-pair flights between earliest and latest departure times**
  - **Keep the original flight schedule as is**
- **Time-Shift**
  - **Shift low frequency flights around the original schedule time to better utilize spare airport capacity**
- **PTP Flight Diversion**
  - **Divert high frequency flights from a congested airport to a nearby PTP airport**
  - **1,000 nm flight range limitation is imposed**

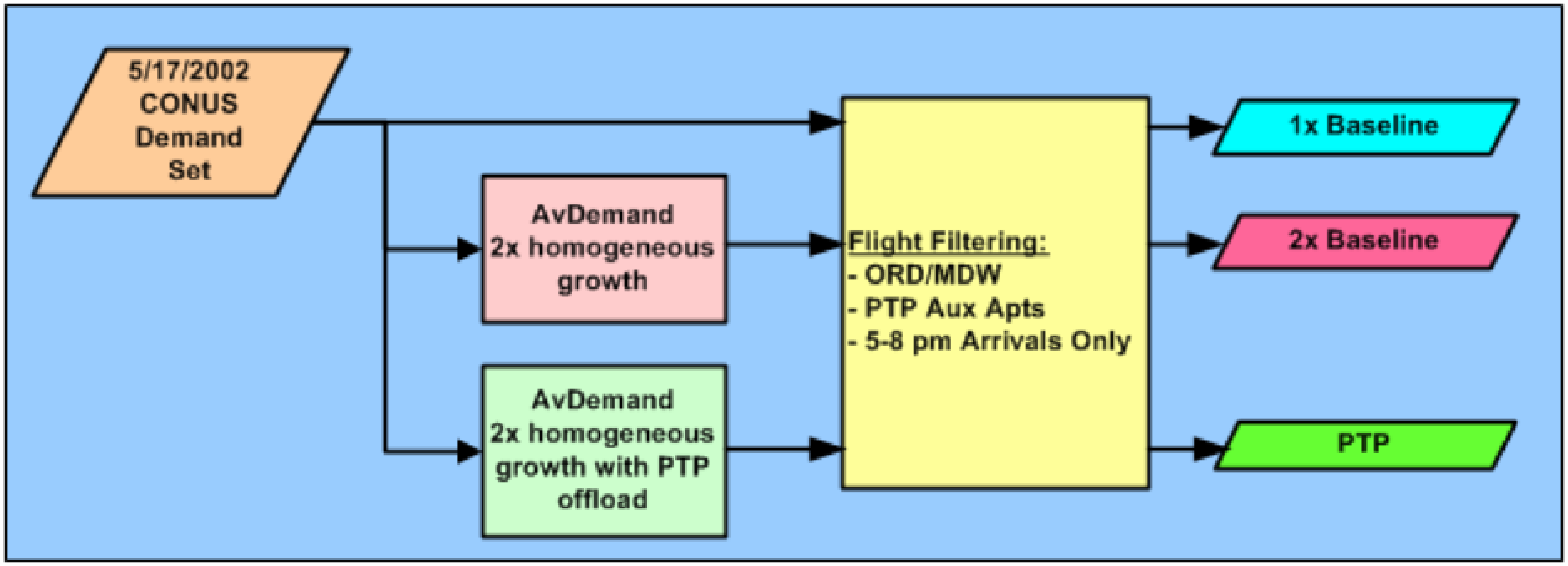
Demand Set Validation



TAF Enplanements and Operations Forecasts

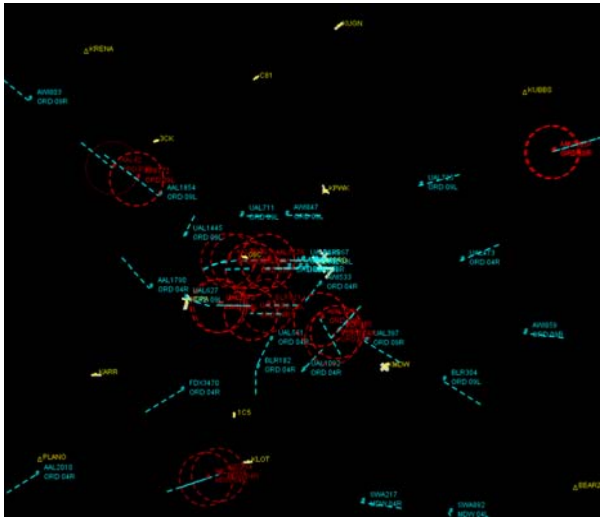


PTP Phase III Extended Terminal Area Simulation: *Demand Generation*

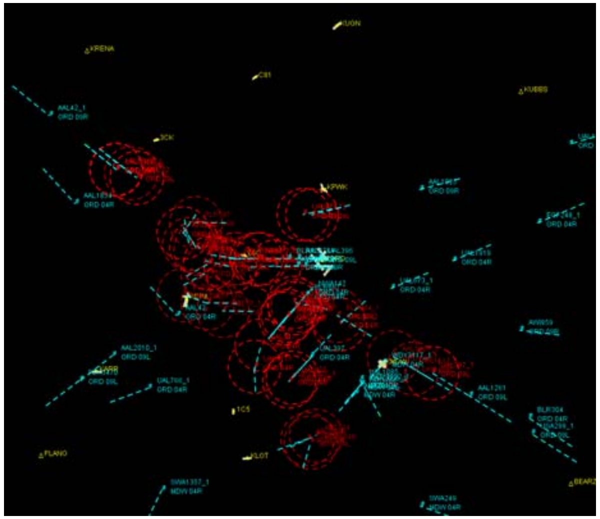


PTP Phase III Extended Terminal Area Simulation: *Traffic Situation*

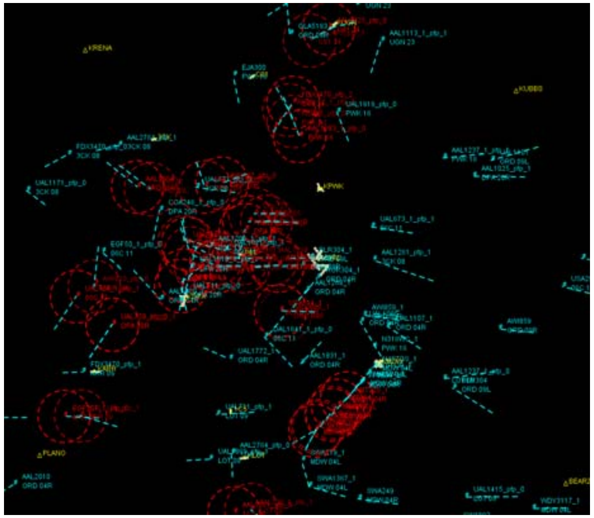
- **Peak traffic loading at 5:53pm CDT *within 30nmi of ORD*:**



1X Baseline



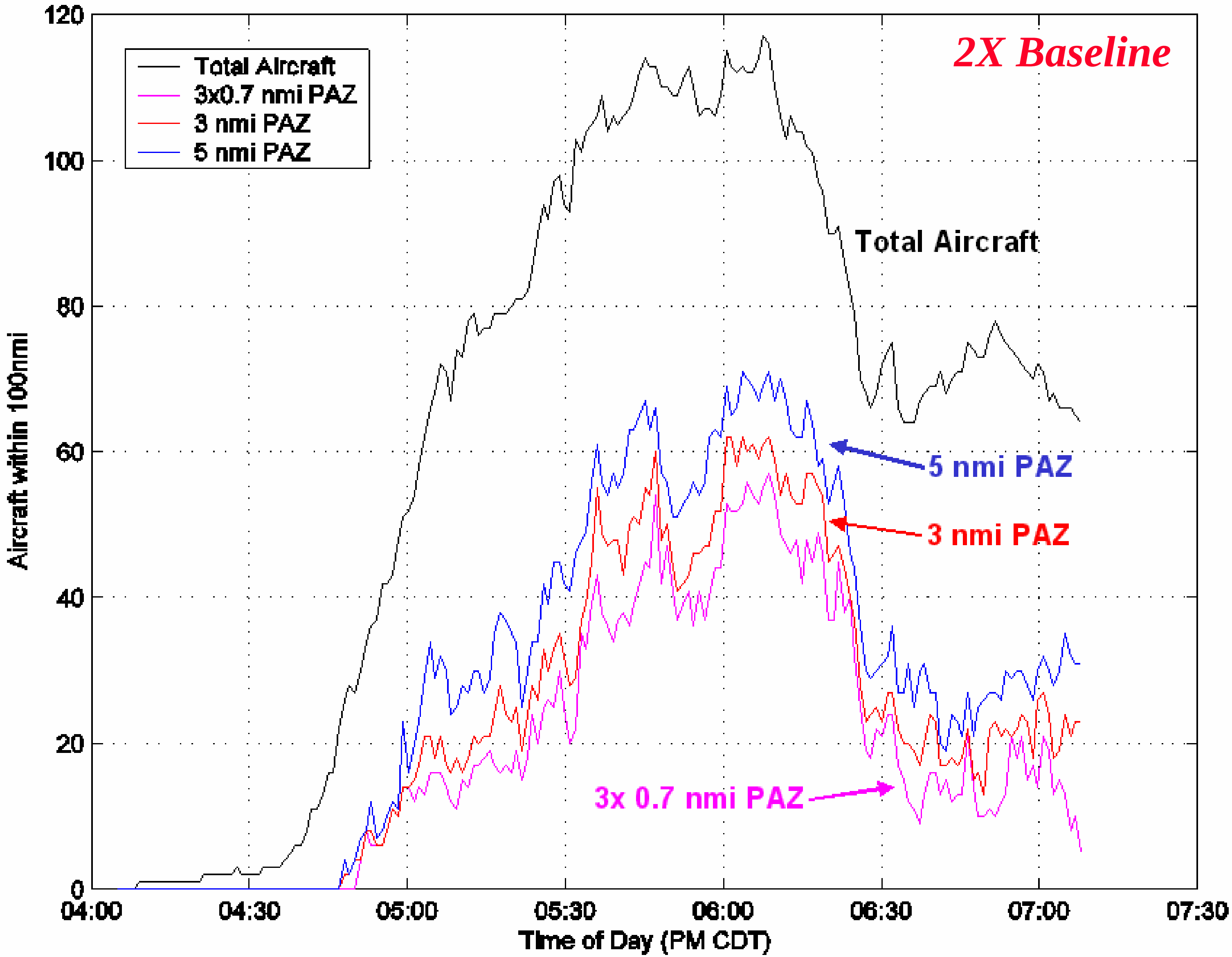
2X Baseline



2X PTP

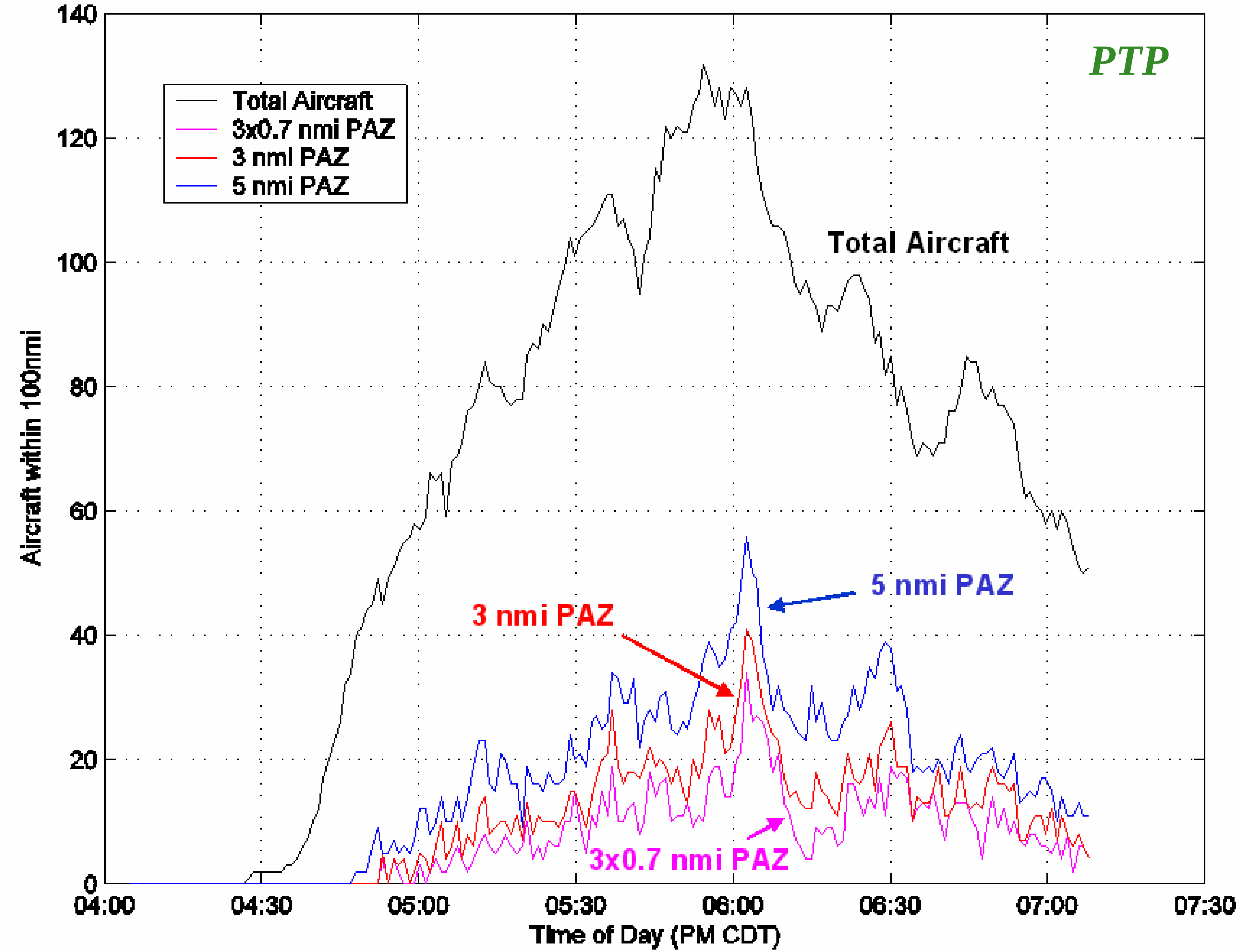
PTP Phase III Extended Terminal Area Simulation: *Results*

- **Aircraft In Conflict vs. Time:**



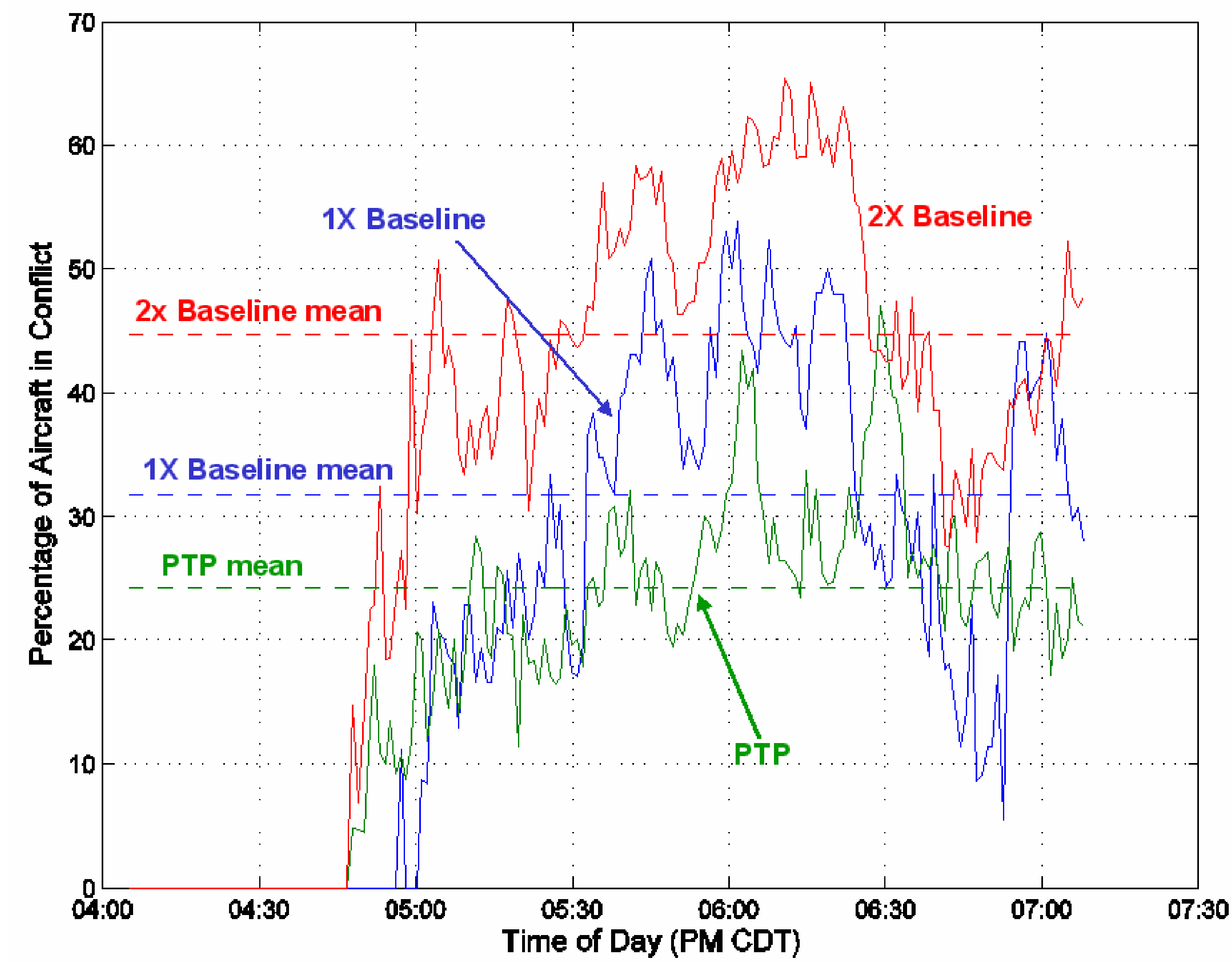
PTP Phase III Extended Terminal Area Simulation: *Results*

- **Aircraft In Conflict vs. Time:**



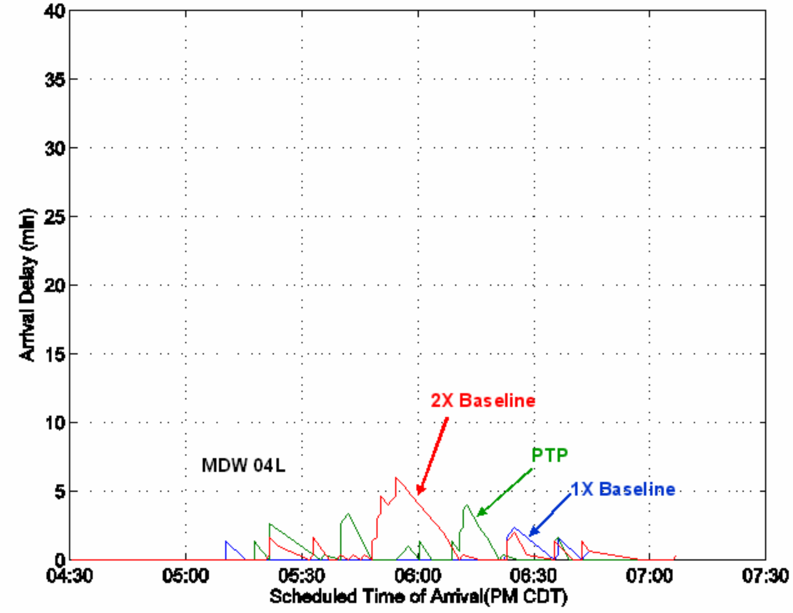
PTP Phase III Extended Terminal Area Simulation: *Results*

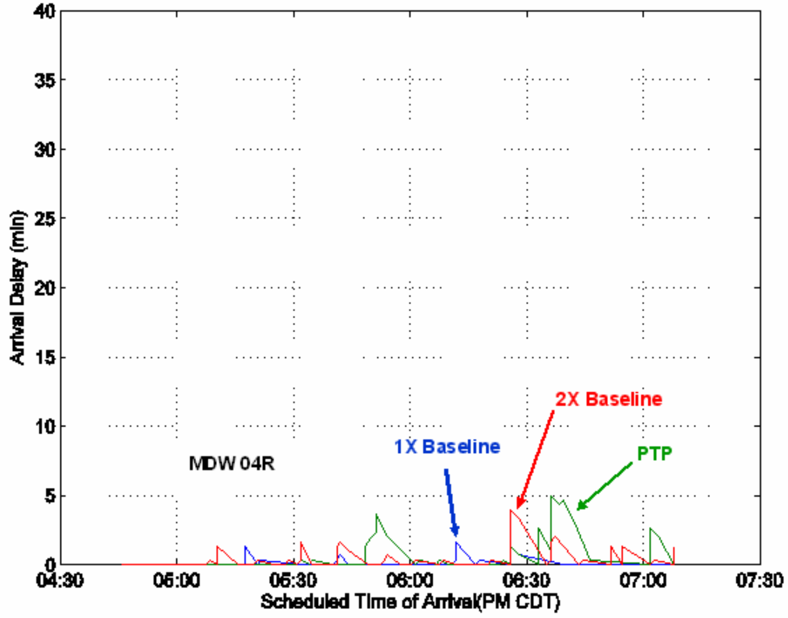
- **Percentage of Aircraft in Conflict:**



PTP Phase III Extended Terminal Area Simulation: *Results*

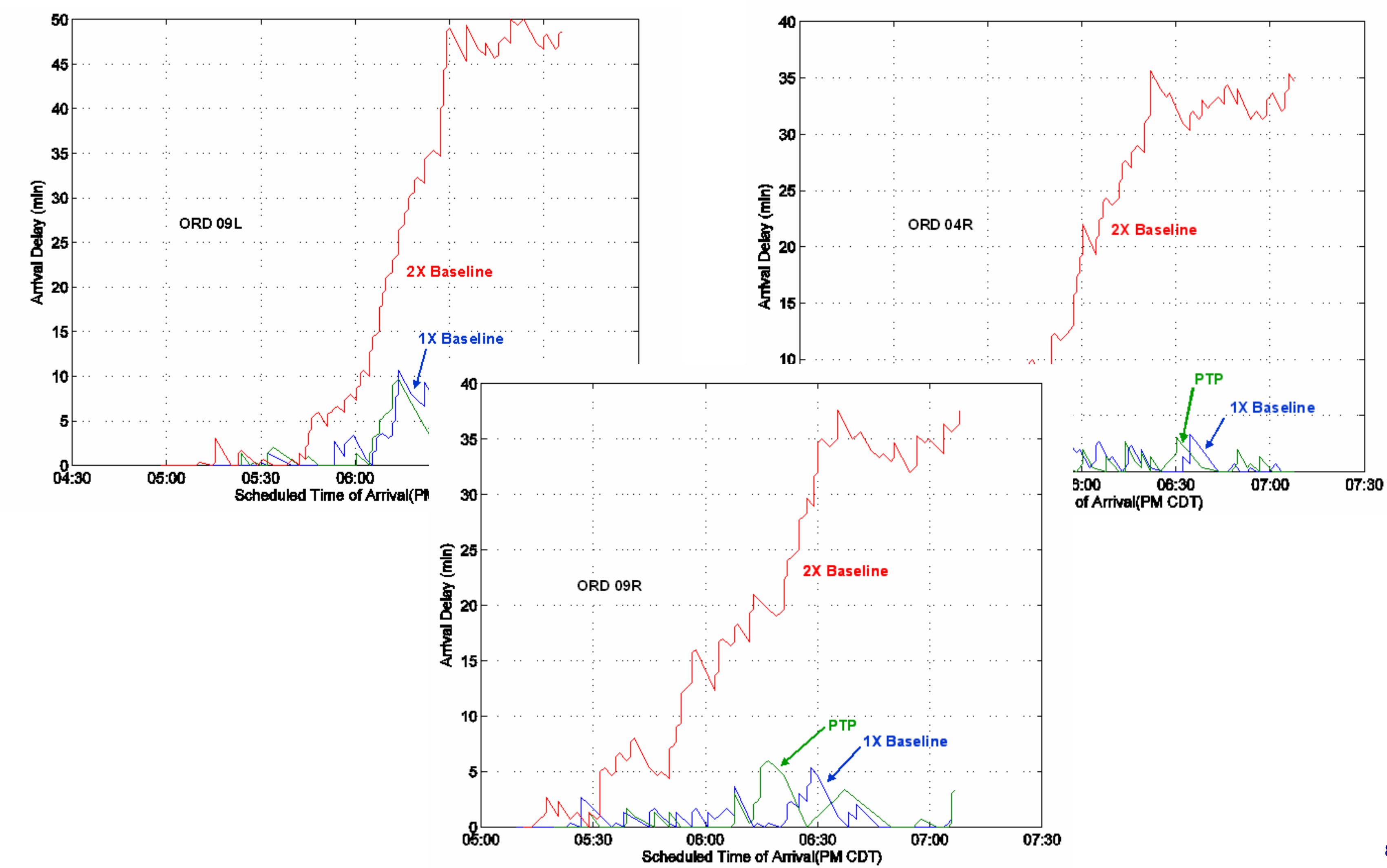
- **Runway Delay Results for MDW Runways:**





PTP Phase III Extended Terminal Area Simulation: *Results*

- **Runway Delay Results for ORD Runways:**



PTP Human Factors Assessment

- Human Factors 2003 survey conducted on-line
- High level analysis on subjective feedback from Pilots, Controllers, and Dispatchers
  - Questions elicited information comparing today's operations to PTP operations on issues including
    - Interface issues – aircraft and control displays
    - Operational and procedural issues – sequencing, flight path negotiation
    - Equipage issues – mixed and non-equipped
    - Communications – data link and VHF
    - Off-nominal situations – weather, emergencies, NORDO
    - Role of automation – automated airport sequencing
    - Separation responsibility – during PTP operations
    - User acceptance – trust in tools and automation
  - Pilots often reported a reduction in difficulty
  - ATCS and Dispatchers often reported slightly higher difficulty

	Response Percent	Response Total
+3 Maximum increase in difficulty	3.4%	1
+2	6.9%	2
+1	17.2%	5
0 No change in difficulty	17.2%	5
-1	20.7%	6
-2	**31%**	**9**
-3 Maximum decrease in difficulty	3.4%	1
Total Respondents		29

Pilot Feedback

	Response Percent	Response Total
+3 Maximum increase in difficulty	12.5%	1
+2	0%	0
+1	**50%**	**4**
0 No change in difficulty	12.5%	1
-1	25%	2
-2	0%	0
-3 Maximum decrease in difficulty	0%	0
Total Respondents		8

Controller Feedback